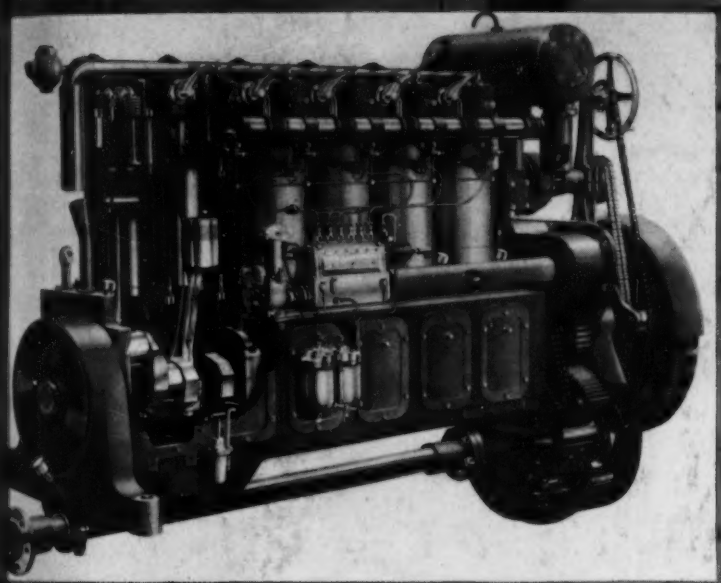
Engineering Materials and Design

UNIVERSITY OF MICHIGAN
JAN 11 1960
ENGINEERING LIBRARY



Simplified Linear Projection

page 10

When it's relays . .

here's news about screws!

We are pleased to announce the production of our Series 320, 325, 590 and 596 Relays on screw terminal bases. The terminals accommodate either solder tags or "crimped" type wire terminals. Screws and sleeves can be supplied numbered as an additional service. Current carrying capacity is 10 amperes maximum in the case of the 320 and 325 types and 5 amperes maximum in the case of the 590 and 596 types. Removable covers (which have been omitted for photographic purposes) are fitted as standard.

Magnetic Devices

A.R.B and A.I.D APPROVED LIMITED

EXNING ROAD, NEWMARKET, SUFFOLK

Telephone: NEWMARKET 3181-4 Telegrams: MAGNETIC NEWMARKET

MD 28

Engineering Materials and Design

★ *The Magazine for Engineering Designers*

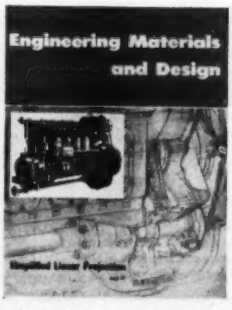
A HEYWOOD PUBLICATION

Vol. 3 No.1 January 1960

EDITOR
H. R. Heap, B.Sc., A.M.I.E.E.

TECHNICAL EDITOR
R. D. Cullum, M.I.E.D., A.R.Ae.S., M.I.A.S.

ASSISTANT EDITORS
F. R. Terrell
P. Burton



COVER shows a portion of an illustration produced by "photolinear projection". Inset shows how the finished result will appear.

Published monthly by HEYWOOD & COMPANY LTD., Drury House, Russell Street, London, W.C.2 (Tel.: TEMple Bar 3422), on the 15th of the preceding month. Annual subscription 35s. sterling per annum ($5.25, U.S.A. and Canada) throughout the world. Single copies to order from all newsagents and bookstalls, 2s. 6d. each (by post from the publishers, 3s. 0d. each). BRANCH OFFICES: Royal Buildings, 2 Mosley Street, Manchester, 2, Tel.: Central 9935; Bayliss House, Hurst Street, Birmingham, Tel.: Midland 5786; 52 St. Enoch Square, Glasgow, Tel.: City 3492; 527 Madison Avenue, New York, 22, N.Y., Tel.: Plaza 9-1171.

© Heywood & Company Ltd., 1960
Must not be reproduced without written permission.

ISSUE AT A GLANCE

page

RELATING PROJECTION TO PHOTOGRAPHIC PERSPECTIVE **10**
Illustration technique for achieving better perspective.
By **Lindley Searle**, M.S.I.A., A.R.P.S.

ADJUSTING YOUR POINT OF VIEW **13**
An instrument for viewing scale models.
By **J. R. Sully**, M.B.E., A.R.Ae.S.

DESIGNING FOR SIMPLER METAL FINISHING TECHNIQUES **18**
How design factors affect metal finishing costs.
By **Adrian Walmsley**.

NEW USES FOR BERYLLIUM IN INDUSTRY **26**
First of two articles on its application and handling.
By **N. A. Hill**, B.Sc.

HOW TO SELECT GASKETS **31**
Choosing the right materials for specific conditions.

OTHER FEATURES

High-strength Glass Ceramics **14**
New Ideas in Design **15**
Who's Who at the Design Conference (main speakers) **22**
Designer's Notebook **24**
Zinc Alloy Pressure Die Castings: Data Sheet **43**
Thermal Linear Expansion of Brass and Zinc: Data Sheet **45**

REGULAR FEATURES

Materials in the News ... **1**
Editorial **9**
Overseas Newsletter **41**
New Books **46**
New Materials and Components **49**
News of Industry **57**

CLASSIFIED ADVERTISEMENTS ... ... facing page 8

Résumés

ÉTABLISSEMENT D'UNE RELATION ENTRE LA PROJECTION ET LA PERSPECTIVE PHOTOGRAPHIQUE

par Lindley Searle page 10

On décrit une méthode d'illustration technique dénommée " projection photolineaire ", mise à point par l'auteur principalement pour son propre emploi. Le but de la méthode est de présenter un objet dans une vraie perspective par l'établissement d'une relation correcte entre la position du spectateur et la grandeur et le caractère de l'objet sans la complexité de la projection lineaire normale.

LA CONSTRUCTION EN VUE DES TECHNIQUES DE FINISSAGE SIMPLIFIÉES

par Adrian Walmsley page 18

L'article explique l'importance pour le constructeur de connaître les limitations de plusieures techniques de finissage. Des procédés de polissage tels que les opérations simples à main ou automatiques, rotation dans un tambour et polissage électrochimique, sont discutés en bref. Les differents types de revètement sont décrits, c.à.d. couches d'oxyde et de phosphate, finissages resistants à la corrosion, galvanoplastie " industrielle " et placage, tous en relation avec leur dépendence des bons éléments de construction. Une courte section est consacrée au traitement superficiel de l'aluminium.

COMMENT CHOISIR LES GARNITURES

page 31

Revue des types de materiaux de garnitures disponibles au constructeur. On discute la composition de plusieurs matériaux de jointure sur base d'amiante, caoutchouc naturel et synthétique, matières plastiques, papier, fibre vegetale, liège, métaux et cuir. Les milieux les plus appropriés à la bonne utilisation de leurs proprietes sont indiqués. Les produits livrés par les fabricants principaux du Royaume-Uni ainsi que leurs applications recommandées sont presentées dans de tableux comprehensifs.

DES EMPLOIS NOUVEAUX POUR LE BERYLLIUM DANS L'INDUSTRIE

par N. A. Hill page 26

L'article constitue la première partie d'une suite à deux parties sur la fabrication, les propriétés et l'application du beryllium. Dans cette section, l'auteur discute le méthodes pour la production de ce métal et l'influence de ces procédés sur ses propriétés et applications ultérieures.

INNOVATIONS DANS LE DOMAINE DE LA CONSTRUCTION

page 15

1. Micromètre électronique à employer sur microscope
2. Sonnette marchante à opération entièrement hydraulique
3. Soupapes pour la regulation de la vitesse d'écoulement et de l'écoulement excessif
4. Pompe à air comprimé d'un type nouveau.
5. Roulement à galets avec un nouveau type de cage

Kurzreferate

HERSTELLUNG EINES ZUSAMMENHANGS ZWISCHEN PROJEKTION UND FOTOGRAFISCHER PERSPEKTIVE

von Lindley Searle seite 10

Ein technisches Illustrierverfahren, die sogenannte „fotolineare Projektion", vom Verfasser hauptsächlich fur seinen eigenen Gebrauch entwickelt, wird beschrieben. Der Zweck des Verfahrens ist, einen Gegenstand in wahrer Perspektive darzustellen, indem man einen richtigen Zusammenhang zwischen der Stellung des Betrachters und der Grösse bzw. dem Wesen des Gegenstands herstellt, jedoch ohne der Schwierigkeiten der normalen Linearprojektion.

KONSTRUKTION IM HINBLICK AUF EINFACHERE NACHBEARBEITUNGSVERFAHREN

von Adrian Walmsley seite 18

Verfasser erklärt, wie wichtig es fur den Konstrukteur ist, die Begrenzungen gewisser Nachbearbeitungsvorgänge zu kennen. Verschiedene Polierverfahren, wie z.B. einfache Hand- und automatische Vorgänge, Poliertrommelung und elektrochemisches Polieren, werden kurz besprochen. Verschiedene Arten der Auskleidung, namlich Oxyd- und Phosphatschichten, korrosionsbeständige Anstriche, „industrielle" und Edelmetallplattierung, werden ebenfalls im Hinblick auf ihre Abhängigkeit von guten Konstruktionsmerkmalen beschrieben. Ein kurzer Abschnitt ist der Aluminiumoberflächenbehandlung gewidmet.

RICHTIGE AUSWAHL VON DICHTUNGEN

seite 31

Eine Übersicht der dem Konstrukteur verfügbaren Abdichtungsstoffe. Die Zusammensetzung verschiedener Dichtungsmittel auf Grundlage von Asbest, Natur- und Kunstgummi, Kunststoffen, Papier, Pflanzenfaserstoffen, Kork, Metallen und Leder wird besprochen und die Umgebungen, in welchen ihre Eigenschaften sich am besten bewähren, sind angegeben. In umfangreichen Tabellen werden die von den bedeutendsten englischen Herstellern gelieferten Dichtungsstoffe sowie ihre empfohlenen Anwendungen angegeben.

NEUE ANWENDUNGEN VON BERYLLIUM IN DER INDUSTRIE

von N. A. Hill seite 26

Dieser Artikel ist der erste Teil einer zweiteiligen Reihenfolge über die Herstellung, Eigenschaften und Anwendung von Beryllium. Im vorliegenden ersten Teil bespricht Verfasser die Verfahren zur Herstellung dieses Metalls und die Weise, auf welche diese Verfahren seine späteren Eigenschaften und Anwendungen beeinflussen.

NEUERUNGEN IN DER KONSTRUKTION

seite 15

1. Elektronisches Mikrometer für Anwendung in Mikroskopen
2. Ein vollständig hydraulisches schreitendes Fallwerk
3. Ventile zur Regelung der Strömungsgeschwindigkeit und Überschussströmung.
4. Eine neuartige Pumpe mit Luftantrieb
5. Ein Rollager mit neuartiger Walzenkäfigausführung.

Резюме

УСТАНОВЛЕНИЕ СВЯЗИ МЕЖДУ ПРОЕКЦИЕЙ И ФОТОГРАФИЧЕСКОЙ ПЕРСПЕКТИВОЙ

Линдлей Сэрль стр. 10

В статье описывается способ технического иллюстрирования — так называемая «фото-линейная проекция»—разработанный автором преимущественно для своего собственного употребления. Целью способа является представление объекта в истинной перспективе путем установления точной связи между положением наблюдателя и размером и характером объекта, при избежании сложности обыкновенной линейной проекции.

КОНСТРУКЦИЯ В СВЯЗИ С УПРОЩЕННЫМИ СПОСОБАМИ ДОВОДКИ МЕТАЛЛОВ

Адриан Уолмслей стр. 18

Автором объясняется значение для конструктора иметь ясное понятие об ограничениях некоторых технических способов доводки. Обсуждаются вкратце такие полировальные процессы как простые ручные и автоматизированные операции, галтование и электрохимическое полирование. Также описываются различные типы покрытий, т.е. окисные и фосфатные пленки, коррозиестойкая отделка, «промышленное» гальванопокрытие и покрытие благородным металлом, с точки зрения их зависимости от хороших конструктивных особенностей. Короткий раздел посвящен поверхностной обработке алюминия.

О ПРАВИЛЬНОМ ВЫБОРЕ ПРОКЛАДОК

стр. 31

В статье дается обзор различных типов прокладочных материалов, имеющихся в распоряжении конструкторов. Обсуждается состав различных соединительных материалов на основе асбеста, натурального и нескуственного каучука, пластмассы, бумаги, растительного волокна, пробки, металлов и кожи, а также указываются лучшие условия их применения. Продукты, поставляемы главными английскими фабрикантами, и их рекомендованные применения приводятся в ряде исчерпывающих таблиц.

НОВЫЕ ПРОМЫШЛЕННЫЕ ПРИМЕНЕНИЯ БЕРИЛЛИЯ

Н. А. Хилл стр. 26

Первая часть статьи в двух частях о производстве бериллия, его свойствах и применении. В надлежащей статье обсуждаются способы производства этого металла и влияние этих процессов на его последующие свойства и применения.

КОНСТРУКЦИОННЫЕ НОВОВВЕДЕНИЯ

стр. 15

1. Электронный микрометр для микроскопов
2. Всецело гидравлический шагающий копер для забивки свай
3. Клапаны для регулирования скорости течения и избыточного течения
4. Пневматический насос нового типа
5. Роликоподшипник с новой конструкцией клети.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Tomorrow's Thermoelectrics

THE USE OF THERMOELECTRIC MATERIALS opens up great possibilities for the development of refrigeration installations which are absolutely noiseless, devoid of moving parts and are easily transformed into heat pumps.

Recent work reported by the Odessa Technological Institute of the Food and Refrigerating Industry has shown that although the power efficiency of thermoelectric cooling has greatly increased with the transition from metals to semiconductors, it is still far behind that of mechanical and absorption units. Calculations based on test data for a large number of domestic refrigerators of both mechanical and absorption types were compared with the theoretical performance for a semiconductor unit. It was concluded that at its present state of development the semiconductor refrigerator will consume several times as much energy as the mechanical type but is approximately level with the absorption refrigerator with electrical heating. The latter is however about three times lower in efficiency than absorption systems employing heat energy. Although the energy characteristics of the semiconductor units may be improved by employing them as heat pumps it is clear that for large installations they do not yet compete with mechanical or absorption types. Where energy consumption is not the major consideration and other factors such as initial cost, reliability, portability or ease of control are dominant, the semiconductor refrigerator is already a practicable proposition and further developments in semiconductor materials having a high thermoelectric force combined with low thermal conductivity and electrical resistance suggest that it will not be many years before refrigeration will undergo a major change.

News from the U.S.A. of a direct method of generating electrical power from heat with efficiencies up to 65 per cent suggests that a revolution in power generating equipment may not be far away. The process known as MHD (magneto-hydrodynamics) is simple in principle although at the moment difficult to execute. It consists in heating up a gas to a temperature of approximately 2,000 deg. C. which ionises it by stripping off electrons from the atoms. The hot gas is then passed between the poles of a powerful magnet which separate the ionised particles of the gas on to electrodes which in effect become the terminals of a generator. The output is direct current and for many applications will need to be converted to a.c.; the Avco Mfg. Corp., who carried out the research work on this project, have some plans for tackling this problem although details have not been disclosed. The commercial success of this new process is largely governed by the development of materials suitable for handling corrosive gases at very high temperatures but research on gas turbines and high speed missiles may well make an important contribution to this.

Acoustic Service for Designers

TO MOST PEOPLE, including engineers, noise is regarded as a nuisance with only arbitrary methods available to reduce or obviate it. Most fundamental study of noise and its effects has been by physicists and scientists, but today engineers are increasingly aware of the problem and in many instances, equally aware of their inability to tackle it.

For this reason, the recently-opened research station now being operated by the Acoustical Investigation and Research Organisation offers considerable potentialities upon which an engineer can call, and their main object may be regarded as a service to industry rather than an organisation where fundamental research is undertaken. The research station is adequately equipped to investigate, test and advise on all acoustic problems whether they are associated with insulation in building construction, or industrial machinery.

Some of its recent work includes the design of the cabin insulation on the new liner, *Canberra*, and various aircraft at present at the design stage. As a member of the Hall-Thermotank group of companies, it claims to be the first independent non-trading organisation of its type to be formed in Britain.

High Temperature Thermocouple

A TUNGSTEN-RHENIUM ALLOY in the form of wire in diameters down to 0.015 in. is claimed to be satisfactory for thermocouples at considerably higher temperatures than any other known metals. This alloy, recently announced by the A.E.I. Lamp and Lighting Co. Ltd., generates a high e.m.f. in conjunction with tungsten and is said to have an almost linear temperature characteristic up to at least 3,000 deg. K. It is suitable for use in vacuum, hydrogen, nitrogen, argon or any other inert gas and it has already proved to be of great use in high temperature research when the use of optical or radiation pyrometers is excluded.

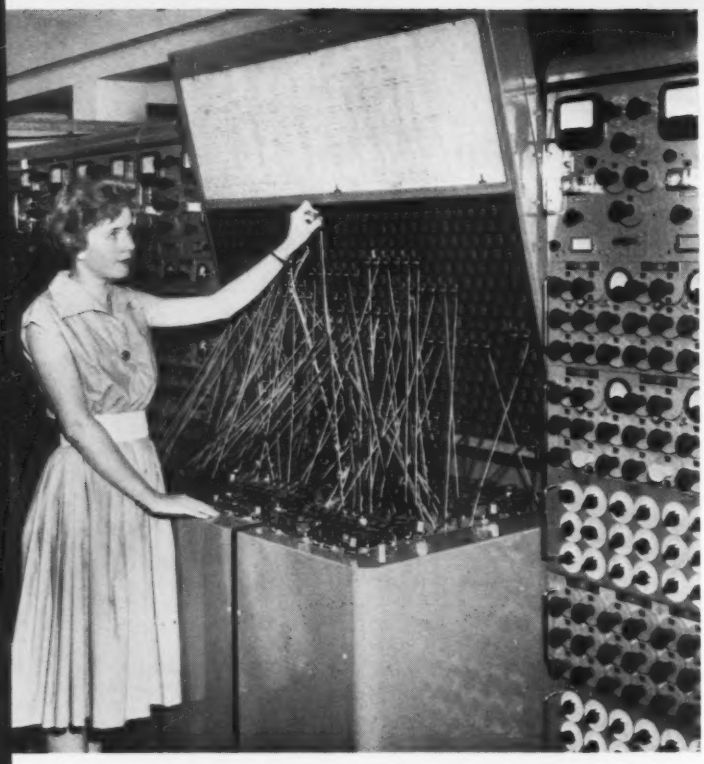
Aspects of Fatigue

STRUCTURAL FATIGUE has been a major issue in aircraft design for many years, and is becoming increasingly important in other branches of engineering. A recent lecture given at the Anglo American Conference, and repeated in London, on "Aircraft Fatigue—A Survey of Current Thought" by R. J. Atkinson, of the Royal Aircraft Establishment, indicated the various aspects which are involved in this study. Some diversity is apparent in the test results of individual components and the results when these components are assembled in a structure. This makes it difficult to form any fundamental theories, which, with knowledge of the material and the loading conditions, can be applied to any particular part.

More research is required on this aspect, the first consideration being, however, the definition of what may be regarded as fundamental. Other aspects of fatigue include the effect of fretting and also the effect of corrosion on cracks which have already commenced. This latter is particularly important for structures designed on a fail-safe principle where they may be in service for some considerable time after a crack has commenced.

A paper read recently at the Institution of Mechanical Engineers by N. E. Frost of the National Engineering Laboratory investigated the "Relation between the critical alternating propagation stress and crack length for mild steel." It was found that the relation between this stress and the length of crack was governed by a parameter involving the product of crack length and the third power of the nominal stress.

In the past, interpretation of experimental results has been confused owing to the fact that the notch fatigue strength was based only on unbroken and completely broken specimens. However, it had been found that cracks could form at the root of the notch, which, at the stress level employed, did not propagate to cause complete fracture, and in this connection it is suggested that the geometry of the notch plays an important part in the resulting data.



NETWORK ANALYSER

Although this network analyser was the subject of a recent demonstration by the Electrical Research Association, it has many non-electrical uses. It can be used, for example, to study vibrations in mechanical assemblies or for the temperature gradients caused by heating and cooling. Its operating frequency is immediately and continuously adjustable over a range of 100 : 1. This enables frequency responses to be plotted and resonances located much more easily than with other analysers.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

TRANSISTORISED RECORDER ▲

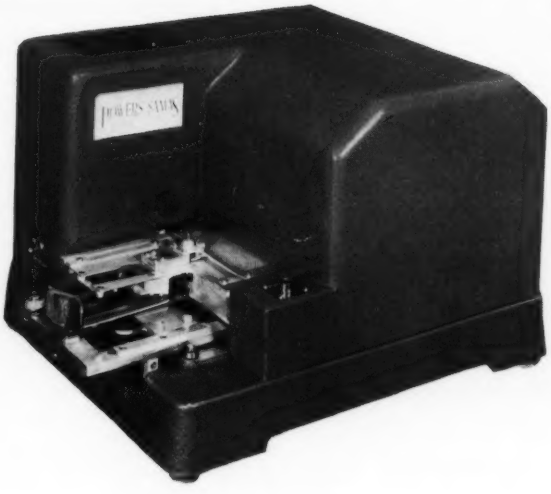
Latest transistorised tape recorder for office work is the Grundig Stenorette T, which can take more than thirty minutes' continuous dictation per casette. Mains-operated, it can be used either individually or in conjunction with a battery-operated Memorette (for the travelling executive) between which casettes are easily interchangeable.

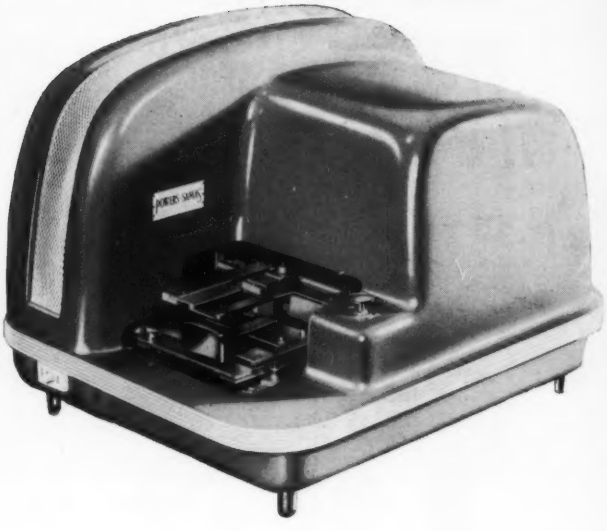
INJECTION MOULDED

The wheels and gears of the Lambert lawnsweeper are injection moulded in one piece from Kralastic nylon. This close-up picture of one of the wheels shows the integral gears. The tiny gear attaches to the axle and drives the unit's sweeper brush. Nylon has several advantages in horticultural applications, for lubrication is unnecessary and the components withstand neglect in bad weather.

DOUBLE DUTY TYRES

From the U.S.A. comes this picture of a pair of Rolli-Tankers, made by the Goodyear Tire and Rubber Co. These giant reinforced-rubber tyres can travel over virtually all types of terrain, and can carry liquid inside themselves. Each is 64 in. high and 42 in. wide, and has a maximum capacity of 500 gallons. Goodyear have a contract to produce 166 of these transporters for a U.S. company.





CHANGE TO PLASTICS

This desk reproducer (by International Computers and Tabulators Ltd.) previously had a sheet metal cover —see left-hand picture—which was noisy and hot when in use. The company's industrial designer, Mr. M. Schejbal, decided on a change to plastics as an answer to improved looks and technical problems. Cellobond polyester and glass fibre are used for the cover and base, making the machine more portable and easier to clean.

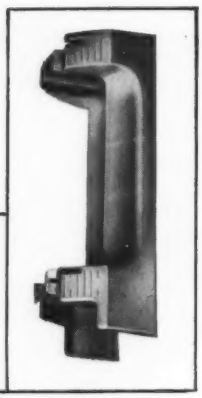
PUNCHED CARD CUE ▶

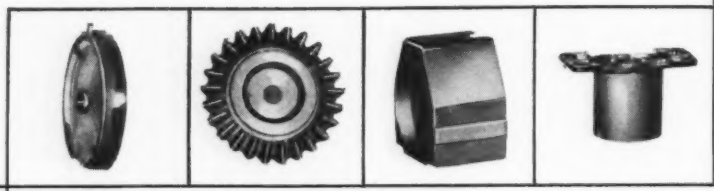
Punched card techniques, already well established in the computer field, are now being applied to stage and studio lighting plots, which demand a constantly changing switching sequence during a performance. This console, designed and manufactured by the Strand Electric & Engineering Co. Ltd., is among recent equipment to be developed on these lines.

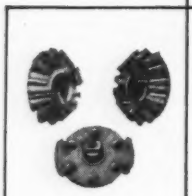
OUTBOARD MOTORS ◀

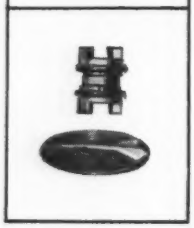
Perkins Outboard Motors Ltd. recently announced their 1960 models to coincide with the opening of a new factory near Peterborough. The plant includes some special high-speed boring and drilling machines introduced to the U.K. for production of the motors. Picture here shows a lower unit of a 35-h.p. motor being assembled; the operator is fitting the drive shaft housing to the gear housing.

WOLVERHAMPTON die castings



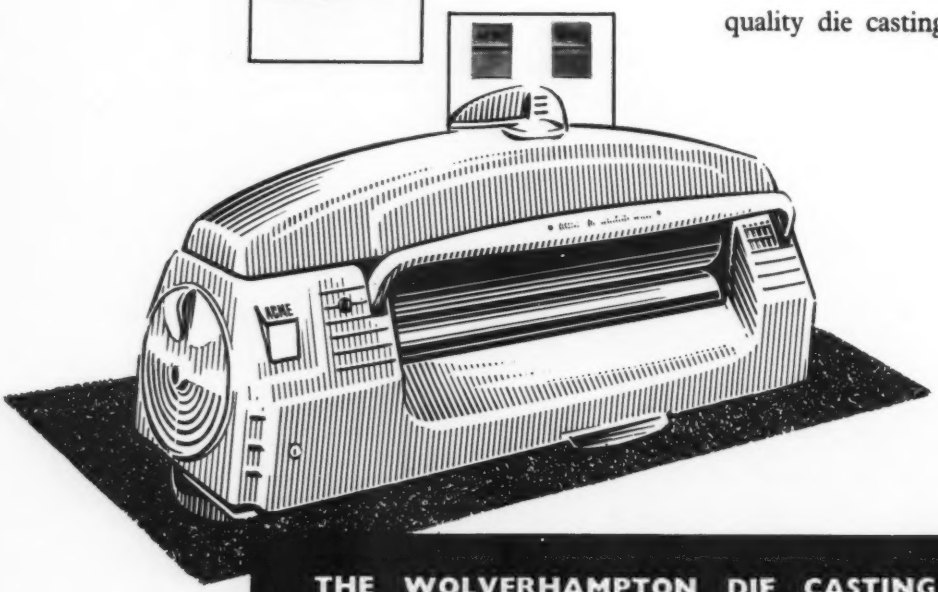






. . . help Acme achieve attractive design appeal for a quality engineered product

"Precision, strength and high quality finish combined with minimum weight — these are the prime requirements of Acme Domestic Equipment Ltd. for their A.160 Wringer". WOLVERHAMPTON die castings meet these requirements, in the largest and most modern plant in the country, backed by nearly half a century's experience in the making of quality die castings.



THE WOLVERHAMPTON DIE CASTING CO. LTD.

Half a million square feet devoted to the production of better die castings.

Graiseley Hill Works, Graiseley Hill, Wolverhampton
Telephone: 23831/6

Pneumatic Platform

With air bearings now well-established and an air cushion supporting the Hovercraft, it must be expected that further examples of pneumatics in action will develop. The latest is a pneumatic platform for moving heavy and large bubble chambers in the Geneva laboratories of the European Organisation for Nuclear Research.

Although the Hovercraft and the platform make use of air jets, the latter is supported on cushions of air which tend to eliminate friction and are sealed as far as possible against leakage. The air used for support is at a pressure of 14.22 p.s.i., contained by a rubber gasket under a surface of approximately 37½ sq. ft. The seal is pressed against the ground by air pressure of approximately 9¼ p.s.i. and with a load of 30 tons on the platform it is possible to push it with two fingers.

In a later development of the platform, four steel discs were used for supporting the load, and one of these is shown in the photograph. The drawbacks to this pneumatic platform are the need for a relatively flat surface free from cracks and the need for operations to be restricted to a horizontal surface, since with the almost practical elimination of friction the vehicle will tend to rapidly slide on a slope. As against these factors, the advantages are the relative simplicity and consequent cheapness; because of the small friction factors, an efficiency of about 99 per cent is obtainable, and the energy required for starting movement is the same as that required for continued movement.

Newest use for air—a pneumatic platform developed in Geneva for nuclear work. Here two development engineers lift the rubber gasket surrounding one of the experimental discs that form part of the platform.

Pure Columbium Mill Products

A SIGNIFICANT ADVANCE in the technology associated with mill products has resulted in the production by the Refractomet division of Universal-Cyclops Steel Corp. of the largest columbium sheet ever made 8 ft. x 3 ft. x 0.028 in. thick, and was produced from a 9-in. ingot of 325 lb., which at the time, was the largest columbium ingot melted.

A second major advance was the casting of a 470 lb. columbium 1 per cent zirconium alloy ingot which will be remelted and cast in order to achieve maximum purity and homogeneity.

The major use for columbium products is in the nuclear industry where its corrosion resistance and low neutron cross section make it useful for many nuclear parts. It is also being considered for leading edges, nose cones and skin material on supersonic vehicles.

Aircraft Engines for Industry

RECENT REPORTS FROM THE U.S.A. show that jet aircraft engines are being used successfully for such industrial applications as pipe line compressors. Among the advantages claimed are that they are already in mass production (whereas industrial gas turbines are not) and their light weight and portability make installation and overhaul easy.

Discussion with British aero engine manufacturers has shown that, while there is considerable interest, such applications require a thorough examination if they are to prove economically attractive. The specific fuel consumption of a jet engine is high and although this may not be significant for peak load or emergency stand-by power units, the continuous running fuel costs may well outweigh the advantages of small space and light weight. One of the deciding factors appears to be the overhaul life, as some manufacturers in this country are not optimistic of anything in excess of 2,000-3,000 hours.

On the other hand, Blackburn Engines Ltd. offer the Turmo free turbine engine for industrial uses, such as driving alternators; they claim that only minor overhauls are needed at 1,000-hr. intervals, but major components are expected to have a useful life of 10,000-15,000 hours. Apart from the high power weight ratio of this engine it is claimed to have unusually good starting characteristics—an important factor for intermittent duties. Bristol Siddeley engines have been ordered by the South Western Electricity Board for driving electric alternators in peak load operation. In this case the Proteus engine, used on the Bristol Britannia airliner, has been used to drive a 3,200-kVA alternator. As the overhaul life when used for aircraft is about 2,000 hours it is expected that under industrial conditions where the engine would be run at a lower rating, a considerable increase could be obtained. Rolls-Royce Ltd., who are quoted as supplying more than twice as many engines for the international airliner market as any other aero engine company in the world, are also optimistic of a satisfactory overhaul life and believe that industrial applications are quite practicable. Another firm interested in this subject is the de Havilland Engine Co. who believe that aircraft engines can be adapted satisfactorily where utilisation is low, on certain pumps used in the chemical industry, for instance. The light weight of these engines not only makes them easily transportable but eliminates the necessity for heavy foundations, an important point in isolated oil fields and mining areas.

Developing Composite Materials

AN INVESTIGATION of composite materials for the future requirements of the U.S.A.F. has been carried out by the Wright Air Development Centre; the greatest emphasis on reinforced materials is for high temperature and high modulus fibre development, and on the mechanism of ablation. One interesting possibility that is emerging is the development of graphite fibres which actually exhibit increasing tensile strength with temperature to a maximum of 15,000 p.s.i. at 2,500 deg. C.

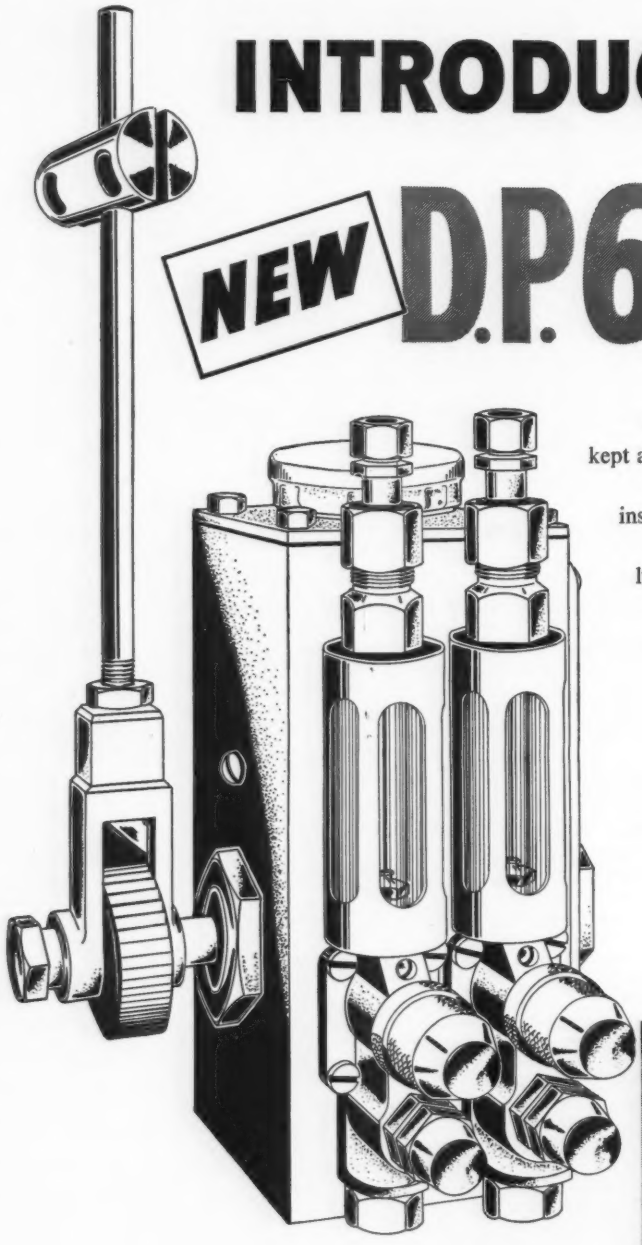
Turbo-jet and turbo-prop engines have seen limited applications of composite materials except for some attempts to use reinforced plastics compressor blades to solve fatigue problems. On the other hand, laminated metal and sandwich construction have become conventional materials for helicopter blades because of improved fatigue life, greater rigidity, better aerodynamic surface and ease of production.

Reinforced inorganic laminates are being examined as a means of reducing the weight penalty in the jump from organic laminates to such materials as glass ceramic and ceramic radomes. Interesting exploratory laminates have been prepared with flexural strengths approaching 11,000 p.s.i. at 540 deg. C. utilising aluminium phosphate reinforced with acid-resisting glass fabric and asbestos felt.

In addition to brazed honeycombs the possibilities exist for ceramic adhesives at elevated temperatures. Much progress has been made in the development of practical inorganic adhesives for stainless steel sandwich construction. Stainless steel shear specimens bonded with glassy adhesives containing fine mesh powders of metallic iron and silicon gave average shear strengths up to 4,200 p.s.i. at 540 deg. C. There appear to be no basic technical reasons for not achieving temperature capabilities as high as 1,100 deg. C. in the future.

An interesting approach in composite materials is one being explored in compliant materials. The hope is to synthesise inorganic polymers which are useful up to 540 deg. C. Composites with useful properties for gaskets, static and dynamic seals and sealants form a preliminary programme that may be an alternative to the inorganic elastomers. Limited success has been obtained with such combinations as molybdenum fibres interpenetrated with silver stainless steel fibres impregnated with tin, and compressed talc and colloidal graphite.

INTRODUCING THE NEW D.P.60 MECHANICAL LUBRICATOR



During the last 60 years, Wakefield lubricators have kept abreast of the changing needs of industry. The DP 60 represents the experience of these years. It is an instrument of precision for feeding oil against pressures up to 1,000 p.s.i. It can be operated by the plant it lubricates on reciprocating or rotating drive. The flow of oil is automatically controlled by the 'start-up and cut-off' of the machine. Efficient lubrication is combined with economy in oil consumption.

ADVANTAGES OF THE DP 60

Welded steel construction gives strength with low weight ratio.

Each feed can be regulated independently.

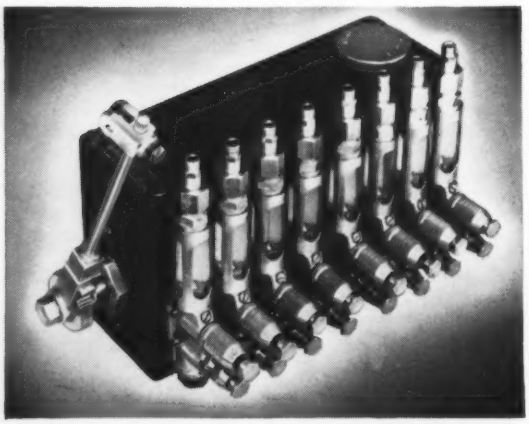
Complete pump unit can be removed and replaced in one assembly.

Patented quick release cap minimises oil contamination.

Up to 32 feeds can be fitted.

Large oil reservoir ensures long working periods between topping-up times.

Built-in perspex oil gauge on the oil reservoir.



WAKEFIELD
INDUSTRIAL LUBRICATORS

Ask for our DP 60 booklet. Send us the coupon and we shall be pleased to mail you a copy with full DP 60 details—by return of post.

PLEASE SEND ME A COMPLIMENTARY COPY OF THE DP 60 BOOKLET

To Dept. PD Wakefield-Dick Industrial Oils Ltd.
Castrol House, Marylebone Road, London, N.W.1

NAME.....

ADDRESS.....

.....

EM

Space-saving Wires

A NEW WIRING METHOD designed to eliminate many of the electrical problems in aircraft and missiles has been developed by Chance Vought Aircraft, Inc. With the new system, bundles of insulated wires are completely encased in a tough, rigid and heat-resistant cover of resin-impregnated glass fibres. This stick-like, hard-coated wiring harness can be moulded into virtually any shape and formed to follow structural contours inside the aircraft, requiring less than half the space needed for conventional harnesses. Harnesses can even take the form of aerodynamic fairings for use outside an aircraft, missile or space vehicle.

The new system will help to obviate broken wires, chafing and crowded installations. It requires minimum maintenance, is abrasive-resistant and resists accidental damage, the weight being considerably less than that of conventional harnesses.

A conventional harness (consisting of 360 wires of a given gauge) forms a bundle 2⅝ in. diameter or, if divided into six smaller bundles, a package 3⅛ in. high and 2¼ in. wide. By contrast, the same number of wires or the same gauge can be carried in a moulded harness section only 1½ in. wide and 1⅝ in. high. Wires thus encased can carry higher voltages, withstand much higher temperatures and electrical overloads, and tolerate vibration far better than conventionally-harnessed wires.

When a group of wires divides off from the main bundle, the "breakout" area is covered with a flexible section of tough, plastics tubing.

The adaptability to external use in various contours makes it possible to plan the wiring bundle as part of a decor, and by changing the colour of the outside jacket it is possible to enhance various colour schemes.

Unlike the conventional system in which each wire is coded as well as numbered, the new harness uses a neutral numbering system which greatly increases the circuit flexibility of the moulded cable assemblies. Since circuit identification no longer is required, any new wire now can be used in a circuit without the need for re-identification of the cable assembly.

A Chance Vought engineer displays sections of a conventional aircraft wiring harness (left) with a new wiring system in which wires are encased in rigid glass fibre covering, resulting in space saving.

Particle Dispersion Strengthens Metals

IN ORDER TO DEVELOP oxidation resistant nickel base alloys with good high temperature properties, three British organisations are making a basic study of factors affecting the high temperature stability of various inert dispersions in a nickel matrix. Consideration is being given to methods of internal oxidation and other deposition processes to produce well dispersed metal/non-metal mixtures. To date, attention has been largely devoted to a study of various oxide dispersions in nickel, some of which have shown good stability after periods of one thousand hours at 1,200 deg. C. Nickel base materials containing various concentrations of thoria have also shown good room temperature properties and stress rupture properties approaching those of Nimonic 80A. Consideration has been given to such factors as particle size and distribution, and development work involves the mechanical mixing of metal powders with the dispersed phase or with solutions of salts that can be decomposed to give the required phases. Promising results are said to have been obtained from the nickel with 1 per cent chromium powder when the powder has been partly oxidised before pressing and sintering. A further combination is nickel with 1 per cent aluminium.

The companies carrying out research on these aspects are the Mond Nickel Co. Ltd., General Electric Co. Ltd., and the B.S.A. Research Centre.

IN NEXT MONTH'S ISSUE . . .

Principal features planned for the February issue of

ENGINEERING MATERIALS AND DESIGN include:

How to Select Lubricating Greases
Survey of the types available and their uses.

Bonding of Threaded Joints
Official tests of commercial cements for thread bonding.

New Uses for Beryllium in Industry
Second of two articles on its fabrication and handling.

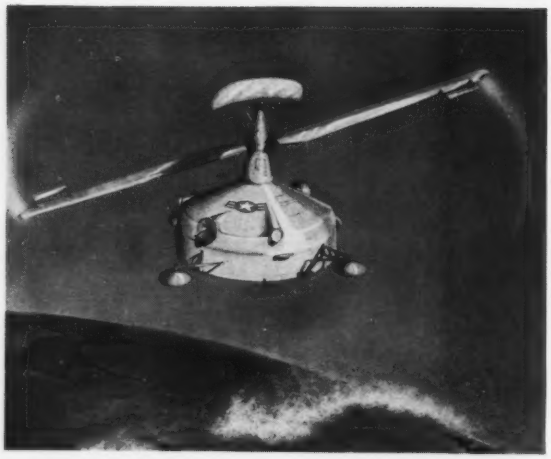
Choosing Electric Motors for Unusual Conditions
Correct types for specific environments.

Glass Fibre Reinforced Plastics
A review of their possibilities and practice.

The Spare Wheel Problem

SINCE EXTERNAL STYLING of motor cars became fashionable and streamlining of the body essential for economic and fast motoring, designers have faced the particularly difficult problem of what to do with the spare wheel. It is a heavy component requiring a strong fixture, but at the same time it takes up much space but must be readily accessible. The problem is specially troublesome with the modern "baby" cars, which although using smaller wheels, have relatively less free space than a limousine.

It was hoped some years ago that the advent of the tubeless tyre would make the carrying of a spare unnecessary, but these hopes have not been fulfilled, and therefore the solution adopted by the Goliath-Werk GmbH for their 1960 Hansa 1100 is worth noting. This company have designed the fuel tank with a dish shaped hollow to accommodate the spare wheel and the air pressure can be checked with the wheel in its regular position. Not many of these cars are to be seen in the U.K., but this design approach is praiseworthy and contrasts markedly with that of some British cars where the spare wheel takes up valuable space in the boot, suggesting either that its accommodation had been forgotten or that the problem was too difficult to solve. Undoubtedly one of the important factors is cost, but more scope may be given to designers if the flexible petrol tank is developed for large scale production, so that the space now occupied by a metal tank could be used for the spare wheel.



This space station envisaged by the Raytheon Co. would be powered by micro-wave energy beamed from the ground and converted to heat energy.

Power Transmission by Radio

THE TRANSMISSION OF POWER through the atmosphere without the use of cable has occupied the mind of many inventors. The Raytheon Company of U.S.A. have recently been awarded a government contract for initial study and research in this direction, wherein micro-wave energy would be beamed skyward from powerful transmitters. This energy would be collected and converted into heat energy which in turn can be transformed into mechanical energy.

The application of this is directed to a flying platform designed to remain aloft for considerable periods of time, and used for missile detection, long range navigation and communications. The important item in this programme is the development of a high frequency, high power micro-wave tube amplifier called the Amplitron.

Micro-waves have long been known to have quasi-optical properties, that is they can be beamed and focused like rays from a searchlight, and found their first practical application in radar. In practically all radar systems the key component is a micro-wave generator called the magnetron, the energy from which can be multiplied many times by the Amplitron.

While the heating effects of micro-waves are a headache to radar design engineers, useful applications for them are found in electronic cookers, micro-wave diathermy units, etc. Thus, much initial work has been done for the efficient conversion of micro-waves to heat.

The efficiency claimed for the proposed sky station is remarkably high, more than 50 per cent of micro-wave power generated on the ground being focused on the airborne antennae, and of this about 35 per cent could actually be delivered to the heat exchangers.

Structural Glass

ALTHOUGH GLASS has been in use for several hundred years, there is surprisingly little reliable data on its mechanical properties. In recent years glass has been increasingly used in structural applications, but there is still a great deal of fundamental data required before engineers can safely predict its behaviour under various loading conditions.

The British Glass Industry Research Association has recently started a study and testing programme from which it is hoped to predict the behaviour of glass panels under different conditions of loading; their first approach is to study the effect of uniform pressure loading on various size panels of different thicknesses with differing edge finishes and edge restraint. The test panels are set up in a pressure box, the load being applied by a water bag and the deflections being measured at some fifty different points. Because of the wide scatter of test results on any one batch of similar glass, a number of specimens will be tested, and from these results it will be possible to obtain a mean value of stress relationships and probability factors which can be applied at the discretion of a designer with the knowledge of the intended application.

This rationalisation of strength values for glass is expected to be a tremendous forward step in the use of glass for future structural application.

Aluminium Strip Windings

THE WEIGHT of electrical welding equipment is frequently a problem, particularly as the demand for portable equipment continues to grow. A large part of the weight is in the transformer and particularly in the heavy copper windings necessary to carry the high welding currents. There are advantages in using aluminium strip or foil to replace copper for electrical windings, but apart from some windings for d.c. solenoids (on, for example, some travelling wave tubes manufactured by the English Electric Valve Co.) the development of foil windings has been very slow in this country. What is claimed to be the first welding transformer to be wound with aluminium foil has just been announced by Ashton-Young Engineering Development Co. Ltd. The air-cooled transformer which is assembled at Remploy's Bermondsey factory is rated at 175 amps (continuous) and the all-up weight of the equipment is only 75 lb., allowing for easy transportation.

Inspection of Honeycomb Panels

BRAZED METAL HONEYCOMB SECTIONS, used extensively where light weight must be combined with great strength, are dependent upon the soundness of the joint brazing, and an inexpensive and quick method of inspection is of great importance.

Research by Picker X-Ray Corp. has led to the development of a photofluorography technique that is sensitive and quick. Elements of the system include a very fine grain 16 in. x 16 in. fluorescent screen in a light-proof hood with a fast, sharp-focusing automatic camera which automatically photographs the fluorescent image on the screen. The adjustment of the equipment for various thicknesses of panels is easily set, and in operation, the head and the detector move across the structure being inspected and automatically scan the entire unit, exposing the sections in rapid sequence.

Results with the system are reported to have been excellent in detecting defects in brazed joints, cell distortion, cell wall wrinkles and excess braze.

E.M.D. on Your Bookshelf

If you would like your 1959 copies of Engineering Materials and Design bound in a single volume, we are able to offer a special service.

The year's issues, from which advertising pages will be removed by us, can be bound at an inclusive cost of 25s.

To avoid unnecessary book-keeping, remittance for 25s. (plus a self-addressed return label, please) must be enclosed with the copies, which should be sent to Binding Service, Engineering Materials and Design, Drury House, Russell Street, London, W.C.2.

Be sure to enclose the 1959 index which is included with this issue.

FOR MORE INFORMATION:—

Blackburn Engines Ltd., 43 Berkeley Square, London, W.1.
Bristol Siddeley Engines Ltd., P.O. Box 3, Filton, Bristol.
Rolls-Royce Ltd., P.O. Box No. 31, Derby.
de Havilland Engine Co. Ltd., Stag Lane, Edgware, Middlesex.
Ashton-Young Engineering Development Co. Ltd., 76 Cambridge Road, Kingston-on-Thames, Surrey.
Raytheon Co., Waltham, Mass., U.S.A.
Universal-Cyclops Steel Corp., Stewart Street, Bridgeville, Penn.
A.E.I. Lamp and Lighting Co. Ltd., Mazda House, 44 Fitzroy Road, London, N.W.1.
Goliath-Werk GmbH, Osterdeich 222, Bremen
European Organisation for Nuclear Research (Cern), Geneva 23.
Chance Vought Aircraft Inc., Dallas, Texas.
Acoustical Investigation and Research Organisation Ltd., 118 Cromwell Road, London, S.W.7.
British Glass Industry Research Association, Northumberland Road, Sheffield 10.
B.S.A. Research Centre, Mackadown Lane, Kitts Green, Birmingham 33.
National Engineering Laboratory, East Kilbride, Glasgow.
Royal Aircraft Establishment, Farnborough, Hants.
English Electric Valve Co. Ltd., Chelmsford, Essex.
Avco Mfg. Corp., 420 Lexington Avenue, New York.

STANDARDISATION FOR BETTER QUALITY

THE British Standards Institution has just announced that the Sixth Conference of Engineers Responsible for Standards will be held on May 11. The last conference, run jointly with the Institution of Production Engineers, was attended by nearly 250 engineers and designers from industry, technical colleges and Government departments. Each year, the conference has grown in size and importance, but we were disappointed that in 1959 the whole emphasis was on "reduction of variety" and practically no mention was made of "maintaining technical quality". One of the main principles observed in the preparation of British Standards is that the interests of both manufacturers and consumers are considered, and we feel that a balanced programme should be arranged at all functions organised by the B.S.I. We hope that in formulating plans for the 1960 conference this will be remembered.

By contrast, the interest of consumers has not been neglected by the B.S.I. in the recent nation-wide publicity given to the revision of B.S. 1224, "Electroplated Coatings of Nickel and Chromium". In recent years we have been very frustrated by statements from organisations dealing with electroplating research that chromium plating is now reliable and of greatly improved quality, because we know from experience that much of the commercial chromium plating has never been worse! The important factor in good quality chromium plating is that the nickel undercoat should be properly applied and of adequate thickness, but while in this respect the revised version of B.S. 1224 is not greatly different from the earlier specifications (it was first published in 1945), consumers should be made aware of its existence and educated to quote not only the specification number but the classification of coating required.

One important change in the new specification is the inclusion of a more stringent corrosion test which should help users to check the quality of chromium plating. Testing of a plating has always been a difficult and expensive job, but the new non-destructive test developed by the British Non-Ferrous Metals Research Association is both ingenious and simple and should be a great help to those organisations who can justify the cost of the equipment. Many consumers have neither the means nor the time to carry out tests, and therefore the labelling scheme introduced by the Mond Nickel Co. for marking goods which have been plated to an approved standard is a good idea. In this system labels will be supplied at cost price to platers for marking their finishes in colours appropriate to the grade of coating. There have been criticisms that the B.S.I. have openly supported a scheme proposed by a firm with obvious commercial interests and that it would be better to set up an independent system of checking plated goods and incorporate a kite mark. Ultimately, it is likely that this will be carried out, but in the meantime the Mond scheme is a useful stop-gap and we wholeheartedly support any proposals which are beneficial to manufacturers and users alike. In any case, the Mond Nickel Co. would presumably not object if nickel plating were eliminated altogether, provided it was replaced by a nickel-containing stainless steel!

The Editor

RELATING PROJECTION TO PHOTOGRAPHIC PERSPECTIVE

"Photolinear projection" is a method of technical illustration that presents an object in true perspective by directly relating the position of the viewer to the size and nature of the object. This article explains how the system works

by LINDLEY SEARLE, M.S.I.A., A.R.P.S.

PROJECTION is a science which enables the draftsman to build up by measurement the exact shape of an object with all its detail from any angle required.

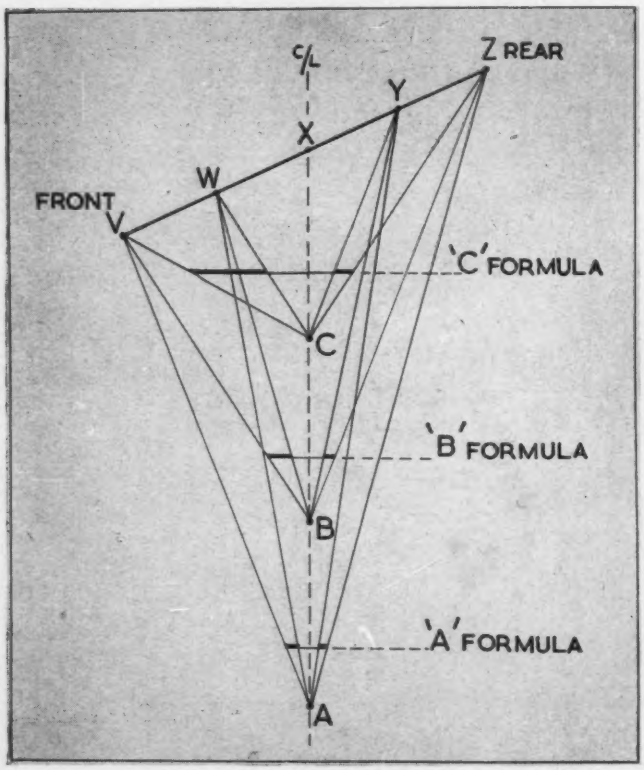


Fig. 1. Diagram to illustrate three positions of viewing an object VZ. Formula "A" is used for the projection of engines and general engineering subjects, formula "B" for motor cars (where little elongation is wanted), and formula "C" for giving emphasis to the portion of an object nearest the eye, like a close-up photograph.

English projection, as its name implies, was originated in this country, and is used by most of the leading engineering firms in the U.K. for engineering drawings. It is a system which calls for three or more drawings per item, i.e., front elevation, side elevation and plan. American projection, also known as third-angle projection, is not quite so detailed, and therefore is not so easy to follow where the building up of projections is concerned.

Both systems, however, come under the general heading of orthographic projection; that is to say, each view has only two dimensions, height and length, or length and breadth, according to the drawing.

If the third dimension is introduced, the problems involved become more numerous and complicated, for now both height and length as well as breadth must be considered. The simplest and most straightforward form of three-dimensional projection is known as isometric. This system has no vanishing points, and therefore an object drawn by this method is unacceptable to the human eye on account of the distortion which is apparent at the rear end of the object. There are variations of isometric projection, employing different set angles, giving a less offensive result, but what about projecting along vanishing lines? Do we set ourselves more difficult problems by so doing?

The moment a vanishing point is introduced into projection, all kinds of difficulties come crowding in. What is the degree of foreshortening required? How is it possible to control foreshortening and keep within the bounds of, say, the kind of perspective usually seen in a photograph which has been taken a reasonable distance from the object? But, is it only foreshortening that is the greatest problem, when it is considered that this deals with the portion of the object which is nearest the spectator?

Linear projection is a system employing a mass of lines radiating across the drawing in all directions. It is so vastly complicated that its uses in everyday problems are very limited; thus other more simple projection systems are used employing vanishing points with varying degrees of success. Some are applied with various mechanical aids, and costly machines are used, but even the use of these mechanical contrivances does not often help in the simpli-

fication of a very difficult problem—which is to be able to produce a drawing along vanishing lines from measurements given and yet have the perspective of a normal photograph.

In the search for an example of an undistorted photograph, it is necessary to understand first of all the meaning of distortion.

In the diagram (Fig. 1) the object VZ is in four equal parts, VWXYZ. The front quarter, VW, is appreciably nearer to the eye than the rear quarter, YZ. Standing at viewpoints C, B and A, three different versions of the same object, VZ, can be seen, although the angle of vision has not been changed, but merely the distance has been altered. Suppose that in front of each of the viewpoints C, B and A, a screen has been placed at an equal distance in front of each.

If lines are now drawn connecting each of the viewpoints with VWXYZ, these will cut across each of the screens, giving different values of foreshortening. It is immediately apparent by looking at the diagram that VCW as it cuts across "C" screen is at least three times greater than YCZ, the rear portion, while at "B" the disparity is only about twice as much. On the other hand, at "A" the view VAW is only about one and a half times greater than the rear YAZ. Thus the farther from the object, the less the distortion becomes.

Three Systems

It was this idea which inspired experiments to produce a system known as photolinear projection, a system of projection scaled from orthographic drawings giving the exact perspective of a photograph taken from "A", "B" or "C" viewpoints.

Formula "A" is invariably used for the projection of engines and general engineering subjects, and is regarded as a most satisfactory viewpoint because it does not cut off too much from the front elevation, as may be seen in the engine shown in Figs. 2 and 3. By comparing the photograph and the drawing of this engine, it will be seen that the photograph is distorted by reason of the photographer attempting to get too close to his subject. There is, in fact, a great deal of difference between the front and rear ellipses, whereas in the drawing the difference is less obvious, giving more front detail.

Formula "B" is used chiefly for the projection of cars where only a certain amount of elongation is required. Some manufacturers like to see the front of their products pulled out, and for this formula "C" is used which is identical in perspective to a photograph taken close up, thus giving emphasis to the portion nearest the eye.

Like the human eye, the camera sees objects in a view gradually getting smaller and smaller as these recede from the viewpoint. It is this decrease in size which can be transcribed as an arithmetic progression in decimals, and forms the basis of photolinear projection. The three-quarter view is generally accepted as the most descriptive view which is usually employed in the building up of illustrations. The line of vision or horizontal may be varied to suit individual requirements, but in large objects the line of vision should come about 5 ft. 6 in. above the floor line to correspond to the eye line of a normal person, thus giving a natural viewpoint.

The first step in the preparation of a photolinear projection is to draw a centre line to each of the front and side elevations of the general assembly drawings, the side elevation being marked off in four equal parts. A three-quarter view is taken of the subject at natural eye level so that the image does not occupy more than a quarter of the negative. This is then enlarged to about 36 in., a suitable working size for the projection. Then the locations of the vertical lines on the side and end elevations are drawn in their corresponding places on the photograph, splitting the side elevation up into four visual sectors which get progressively smaller.

The vertical measuring axis is placed at the leading corner of the photograph where the side and front base lines meet, its length corresponding to the height of the object. This is reckoned as one whole unit, all the other measurements being decimals of this measurement. Thus the nearest quarter of the side elevation may have a length value of 0·8 of the vertical measuring axis (VMA) followed by 0·7, 0·6, 0·5, of the three following quarters. On the other hand, the front elevation halves may have values of 0·7 and 0·5 to the total height (VMA). The resultant framework drawn of the photograph is then transposed to the drawing board, and vanishing tracer lines rigged up. The relevant decimal values on the photograph are then used to transcribe the measurements given in the general assembly drawings on to the projection to produce the same characteristics as a photographic perspective.

In the case of the Standard Vanguard III, the eye level was taken at rooftop level, and, as a prototype was available, a photograph of this was taken so that the image occupied less than half the negative. It was found on enlargement that a small percentage elongation was called for: no more than 8 per cent for the bonnet, and 6 per cent for the front door, leaving the rest to look after itself.

From general assembly drawings the measurements of the engine, transmission, under bonnet details, and front

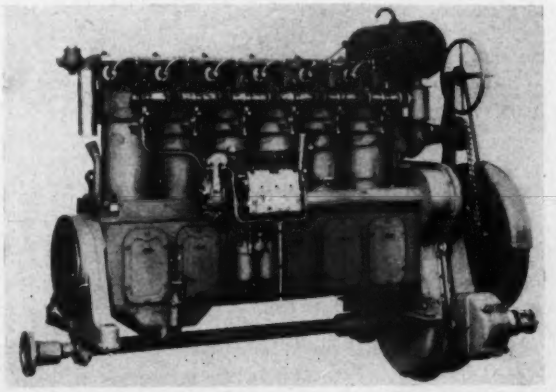


Fig. 2. Photograph of Kelvin marine diesel engine. There is distortion at the front end caused by the photographer being too close to his subject.

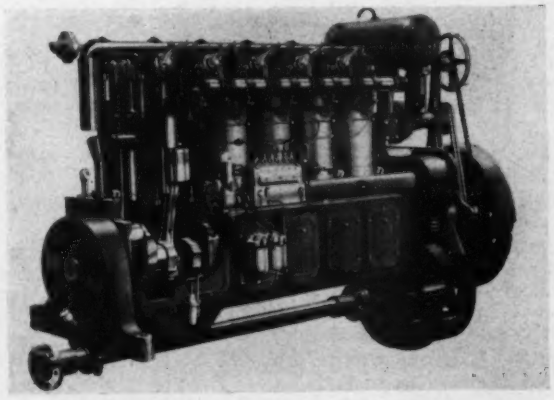
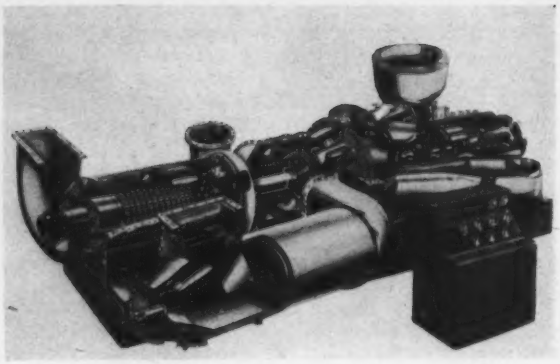


Fig. 3. Drawing of an engine similar to that above projected from measurements given in engineering drawings by the "photolinear" system using formula "A".



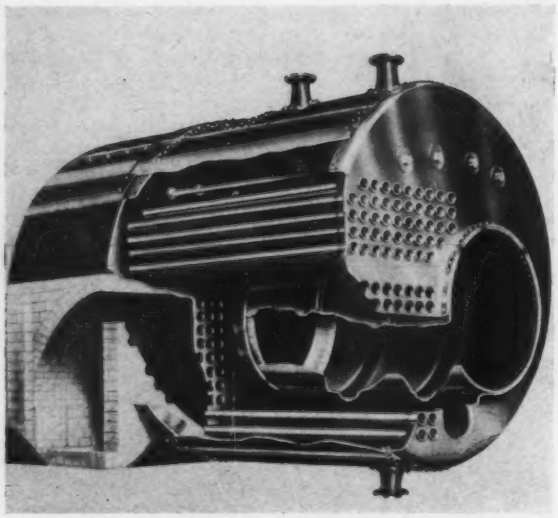


Fig. 4. Left. A Paxman boiler projected by photolinear formula "A" and finished in half-tone airbrush.

Fig. 5. Top left. Cutaway drawing of a Standard Vanguard III projected from measurements given in general assembly drawings and using formula "B".

Fig. 6. Above. Three-quarter top view of a Ruston Hornsby gas turbine which has been photolinear projected (formula "A") and sectioned. All measurements were taken from engineering drawings without reference to actual plant.

seats, etc., was transcribed by formula to the now corrected outline, working with vanishing lines. The pencil projection was then taken to the works and checked for extraneous detail left out of the G.A. drawings, thus completing the drawing. The final stage was now reached, which was the application of four-colour airbrush on plastics sheet.

The advantage of working on plastics sheet is that, if there are any last-minute modifications, these can be incorporated in the drawing without damage to surface, and chemical is used to erase the portion to be modified. The art work is fixed with a special varnish which makes it very durable.

Working Ahead of Product

The above forms a general description of the methods employed in the production of most of the examples of this system of projection, except in certain cases. Sometimes a manufacturer is faced with the problem of requiring an urgent illustration of his future product when no photographs or general assembly drawings are available. The work then becomes a little more difficult, requiring the sorting and fitting together of vast numbers of drawings. Building up this kind of a drawing without any kind of pictorial reference available is to have absolute faith in the system, and may be compared to blind flying, where the pilot has to rely on his instruments. The saving in time is very considerable of course, because a fully-finished drawing can be produced months in advance of the engineering product.

Photolinear projection may be used as an aid in elucidating some design problems, particularly in car bodies where curves play an important part. From draftsman's drawings, a three-quarter view projection is prepared to formula "B", which gives a matter-of-fact view of the model. Any offending curve or detail on the projection may be modified by a visual stroke of a pencil, and the alteration transcribed back on to the orthographic drawing by formula, this saving a great deal of time and effort in the preparation of the plaster model.

A question often asked is how much training is required for a person to produce satisfactory finished illustrations projected from G.A. drawings.

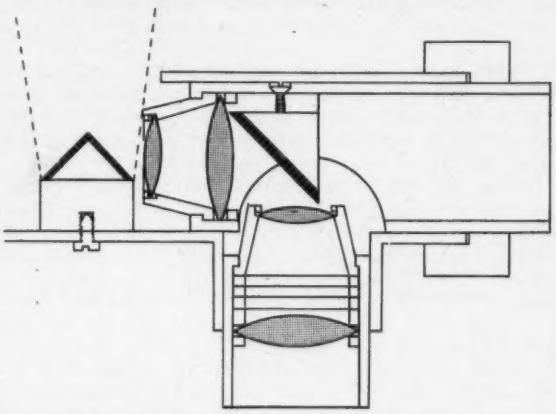
The first requirement is a practical engineering apprenticeship involving the making of parts from engineering drawings, and general assembly work. By this the pupil gets to know the relationship of engineering drawings to the product, and becomes thoroughly conversant with engineering practice. This is followed by a spell in the drawing office and an insight into drawing neat diagrams. From this it is advisable to proceed to the service technical department on the illustration side, and prepare illustrated parts lists using one of the projection systems. During this time a course of photographic retouching should be taken at one of the technical schools, this involving the cutting of thousands of masks, and being taught the art of shading with an airbrush. To add to the already formidable list of "musts", a knowledge of printing is essential, and the ability to foresee how the application of colour to a drawing will produce the desired effect. The pupil must have the ability to think clearly when confronted with the multiplicity of problems in geometry which are the basis of projection, and also to be able to make simple and accurate mathematical calculations which are no higher than G.C.E. level. Above all this, a love of mechanical detail is of paramount importance.

ADJUSTING YOUR POINT OF VIEW

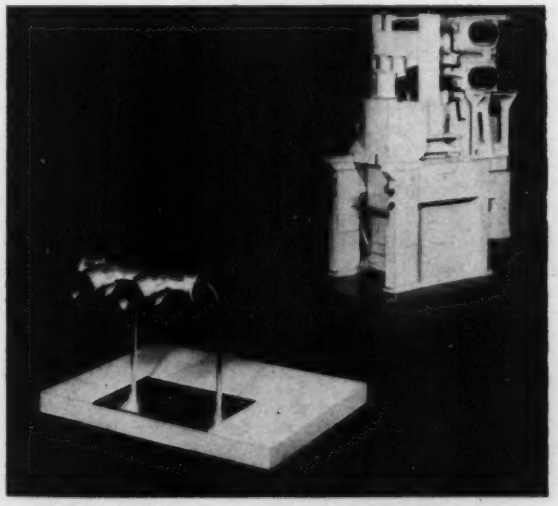
The author describes an instrument developed to eliminate the distortion often found when viewing small-scale models with the naked eye

by J. R. SULLY, M.B.E., A.R.Ae.S. *

THE use of models is generally accepted in most branches of engineering today as a sound practice in the design and development of products as diverse as a telephone and a complete atomic power station. Apart from its advantages in purely functional design, it provides a valuable opportunity for seeing the visual appeal that a product may be eventually given.



Optical system for the right eye of the instrument is shown here full size. The optical system using lenses and mirrors is complex, although the actual apparatus is relatively simple.



The instrument is shown here set up for viewing a small-scale model of a 10 ft. high circuit breaker.

Dr. E. W. Seward, of W. & T. Avery Ltd., in the paper he read at the recent Council of Industrial Design conference held on the subject of industrial design in engineering, emphasised the need for models to be accurate in both detail and size. This is of the utmost importance, for it is extremely difficult to judge the appearance of a finished product from a scale model, particularly if the outer surfaces have rounded contours, as may be the case with a steam turbine generator or a motor car.

At the same time, it is true that models of larger products are expensive and, very often, impracticable to manufacture to full size.

Personal experience has shown that the high cost and the time and effort involved in producing full-scale models are significant influences in deciding whether a finished model is satisfactory in appearance. I have found myself more inclined to introduce minor changes than to take the drastic step of scrapping the model and starting again.

However, I found that these factors were less serious if scale models were used, although their very size gave a rather distorted impression of the final result. This was overcome by designing and making an instrument which effectively reduced the distance between the eyes according to the scale of the model, for I found that the deception of ordinary scale models is caused by the human inability to see round an object. Equally important, it follows that the relative bulk and weight of two or more component parts of a product become even more deceptive on a scale model. For example, a bracing or rod (which is, in effect, a long, small-diameter cylinder in relation to the much larger body of the main product) may look satisfactory on the model, but will seem much more hefty in full scale. Other optical tricks of this kind are likely to occur with scale models viewed with the naked eye.

The basic principle of the instrument which was found to eliminate most of these problems is shown in the drawing on this page. It will be appreciated that, by adjusting the distance between the reflectors or prisms, the instrument could be used for models of various scales. I have at different times used both mirrors and prisms, but the latter were more effective for general purposes.

When viewing a model, the accuracy of the impression is increased by fixing the instrument at normal eye-level to scale. If possible, the background should preferably also be to scale.

For practical purposes of production, such as the making of templates for tools and the preparation of manufacturing drawings, an actual full-scale model may eventually be justified, but an instrument of this kind can still be used with advantage in the earlier stages.

Acknowledgment is made to K. F. Davis and R. C. Dayson, of English Electric instrument division, for preparation of experiments illustrating the principle applied to a model circuit breaker.

* *General manager, English Electric Co. Ltd., Stafford.*

HIGH-STRENGTH GLASS CERAMICS

GLASS ceramic materials, which were developed for industrial applications only in comparatively recent times, may be regarded as being the most significant technical advance in this field since the discovery of borosilicate glass at the beginning of this century. One of the most well-known of these, called Pyroceram, is a tough, heat-resistant material, harder than high-carbon steel, lighter than aluminium, many times stronger than plate glass. With these characteristics, a multitude of applications in industry is being envisaged.

Pyroceram was developed originally for domestic applications, but its ability to withstand sudden and extreme changes in temperature in the range found in outer space—and without affecting its excellent electrical properties—indicates a promising future for missile nose cones, as well as in the electronic and aircraft industries, and in the manufacture of such varied pieces as cylinders, pump parts, heat exchanger tubing, pipe caps, thread guides and non-lubricated ball bearings.

It is essentially a material that has been converted into a crystalline ceramic from its original glassy state by the use of heat treatment. Certain nucleating agents are added to the glass batch, which is then melted, formed and cooled. When the glass is reheated at temperatures which permit crystallisation, crystallites are formed throughout the glass body, each crystallite acting as a centre for crystal growth as the heat continues. Composition of the glass and heat treatment determine the type of crystallisation.

The resultant material is an opaque ceramic the same shape and size as the original glass article, except that the minute volume changes due to altered density and expansion coefficient of the crystalline material may be expected.

To demonstrate the toughness of Pyroceram, a laboratory worker uses a white-hot cone of the material to drive a nail into a wooden plank.

Properties of Pyroceram

		9606	9608
Specific gravity (25°C)		2·60	2·50
Water absorption, %		0	0
Porosity		gas tight	
Softening temp., °C.		1,250	1,250
Mean specific heat, 25–400°C.		0·230	0·235
Thermal conductivity, c.g.s., 25°C. mean temp.		0·0087	0·0047
Thermal expansion coefficient, × 10⁷ (25–300°C)		57	7–20*
Modulus of elasticity, p.s.i. × 10⁻⁶		17·3	12·5
Poisson's ratio		0·245	0·25
Modulus of rupture (abraded), p.s.i. × 10⁻³		20	16–23
Hardness, Knoop 100 gm.		698	703
Dielectric constant, freq. 10⁸ at 25°C.		5·58	6·78
	300°C.	5·60	—
	500°C.	8·80	—
Dissipation factor, freq. 10⁸	25°C.	0·0015	0·003
	300°C.	0·0154	—
Loss factor, freq. 10⁸	25°C.	0·009	—
	300°C.	0·086	—
Volume resistivity, log 10 (ohm-cm.),	250°C.	10	8·1
	350°C.	8·6	6·8

* Depending on heat treatment.

This material is stronger and harder than the parent glass, has a greater scratch and impact abrasion resistance, and is characterised by improved thermal and electrical properties.

Glass ceramics are approximately 40 per cent harder than borosilicate glass, as measured with indentation tests, and in their initial glassy state they can be ground by standard glass finishing methods. Precision grinding can easily be carried out in their crystalline state.

Of the two types of Pyroceram that are made by Corning Glass Works in commercial quantities, one is called Code 9606, specifically developed to give uniform electrical properties at microwave frequencies and elevated temperatures for missile radomes, although other desirable properties make it suitable for use in other fields. The other type, Code 9608, is a white, opaque fine-grained crystalline material with high mechanical strength, extremely low coefficient of thermal expansion and a hardness substantially higher than that of glass. Developed primarily as a general-purpose material, it can be formed by all automatic glass manufacturing processes, and can be blown, drawn as tubing, pressed and rolled. Due to its low expansion and high mechanical strength, it has a thermal shock resistance surpassing most glasses or ceramics, and its hardness approaches that of case hardened steels.

During development tests the type 9608 showed good insulating properties comparable with those of most of the borosilicate glasses. However, it is not to be compared to Code 9606 for high frequency insulation at elevated temperatures. Chemical resistance to strong acids and alkalis is slightly less than that of borosilicate glasses.

The material, Code 9608, lends itself to easy forming by any of the high-speed automatic glass-forming methods and there are no restrictions on sizes and shapes other than those imposed by normal glass-making techniques. Tolerances of the same order may be observed.

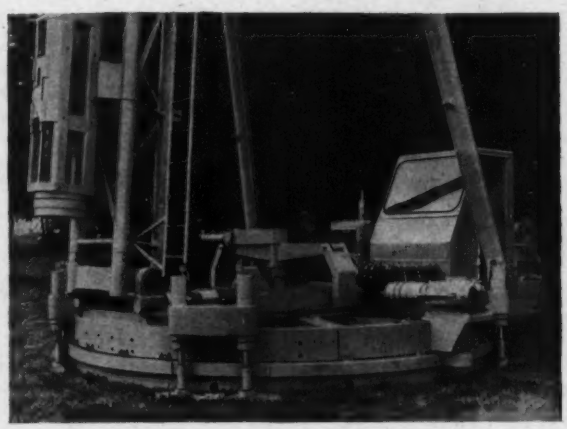
Tests indicate that 9608 will, when used as a bearing, operate under varying load conditions at temperatures as high as 540 deg. C., at loads less than half those expected of standard steel bearings. Under actual running conditions the material will not deform or soften under the high temperatures.

Tubing made from 9608 is being tested for use in heat exchangers, particularly where temperature differentials are great and where slurries or liquids with abrasives are being run through the exchanger. Other applications include brake shoes, bulkheads for nuclear surface vessels, curtain walls, structural parts for aircraft and piston heads.

NEW IDEAS IN DESIGN

Outstanding products in current manufacture

An All-hydraulic Walking Pile Driver



THE British Steel Piling Co. Ltd. have recently produced a pile-driving plant in which fully hydraulic operation of the winch and all motions, including raking, rotating, leader adjustment and travelling, has been achieved. Apart from bolted construction of the large assemblies for dismantling, the frame is all-welded.

The overall height of the frame measured from ground level to the top of the head unit is 67 ft. approx., and the maximum length of pile that may be pitched from ground level under the hammer is about 50 ft., according to the type of hammer.

Triangular in form, the leader unit comprises three main longitudinal tubes with horizontal and inclined tubular bracing. The two front tubes serve as the guide members for the hammer, which is fitted with resiliently mounted back guides arranged partially to embrace the tubes. The basic unit is 19 ft. in length and three such units together with the back strut unit, the head sheave unit, the bottom swivel unit and the lower leader extension, are connected by easily assembled muff couplings.

The frame base consists principally of two circular box-section rings resting one on top of the other. The frame structure and machinery are carried by the upper ring which rotates about the lower ring on specially lubricated surfaces, the lower ring being rotated by a chain around its circumference, driven by a hydraulic-motor-driven sprocket. The lower ring rests on the ground. Hydraulic jacks, mounted on the upper base ring, are provided for levelling.

Movement of the plant is achieved by means of hydraulic walking gear carried on an inner ring which may be rotated within the upper base ring. The walking gear consists of two inclined hydraulic jacks hinged at one end to the inner ring and at the other end to a foot plate through which pressure can be applied to the ground. Operation of the jacks transfers part of the weight of the plant to the walking foot plate, while the horizontal component of the jack thrust moves the plant forward in the desired direction. The walking gear may be rotated by power through one revolution relative to the base structure and may, therefore, be set in any desired direction of travel, being retracted within the base while the plant is operating.

The leader is supported by two tubular back struts, the upper ends of which consist of hydraulic jacks which enable the leader to be inclined both forward and backward.

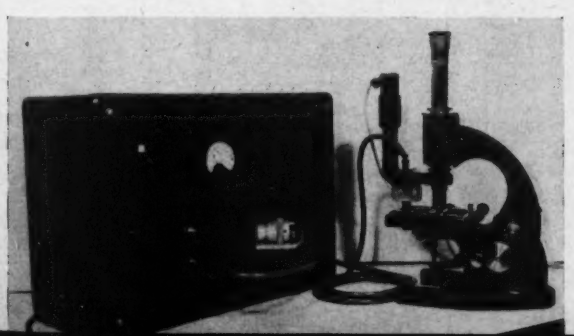
Power is provided by a Fordson six-cylinder diesel engine coupled to a hydraulic pump which delivers fluid to the jacks operating the raking, leader adjustment, travelling and levelling motions.

All the control valves are mounted on a console in front of the operator's position inside the cab, which provides protection from the weather while allowing the operator full view of all motions.

Electronic Micrometer for Use on Microscopes

ALTHOUGH some microscopes are provided with calibrated measuring slides and built-in measuring graticules are sometimes employed, fine measurements are difficult by direct means. For this reason, microscopes are widely used as a means of observation but seldom for measurement.

An electronic micrometer, developed by Wayne Kerr Laboratories, enables measurement to be made of any movement of the microscope tube relative to the object being viewed, a distance of one-thousandth of an inch being discriminated to 1 part in 1,000. No contact with the specimen under observation is necessary, and, since there are no moving mechanical parts, it is claimed that the high order of accuracy achieved is maintained over years of continuous use.



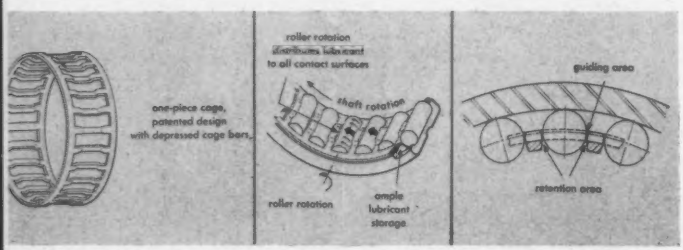
Measurement is by means of an a.c. bridge operating in conjunction with a non-contacting probe. A three-terminal arrangement enables the capacitance of the probe to be balanced out in the bridge circuit; measurements can be made on objects situated up to 75 ft. from the main instrument.

Because no physical contact is necessary, accurate determination of temperature coefficient, moduli of elasticity, rigidity and bulk, Poisson's ratio and dilation are said to be possible on fragile samples. The equipment is stated to be particularly suited to measurements on rotating objects and for monitoring distance with reference to a predetermined value.

The instrument is designed to measure distances in the range 0-45,000 micro-in., with a minimum practical separation of 100 micro-in. and an accuracy of 1 per cent over the full range.

Roller Bearing with Novel Cage Design

A NEW series of channel-shaped outer ring roller bearings introduced by the Torrington Co. features a new, patented, cage design. Utilisation of the cage design is claimed to permit application of the bearings at speeds higher than those attainable with full-complement types. Longer and larger rollers in these standard inch-size cage-type roller bearings result in greater capacities than heretofore available. Made in sizes ranging from ¾-4-in. bore, and designated as series HJ, the bearings may be applied directly to hardened and ground shafts or used with inner rings which are also available.



The distinctive one-piece cage design separates roller-guiding and roller-retaining functions by employing a cage bar depressed within the roller pitch circle. Roller guidance takes place at the ends of the rollers, and at the pitch line where guidance is most effectively accomplished with minimum internal friction and generous provisions for tion of the cage bar which is always out of contact with the rollers during operation, preventing needless wiping away of lubricant common with ordinary cylindrical cages. Lubricant circulates freely through the bearing.

The ends of the rollers are a few hundred-thousandths of an inch less in diameter than the middle. This end-relief design prevents stress concentration at the ends of the rollers and ensures uniform load distribution.

The new design is claimed to give extremely long service life and to combine highly effective roller guidance, minimum internal friction and generous provisions for lubrication to allow operation at higher speeds.

An Unusual Air-driven Free-piston Pump

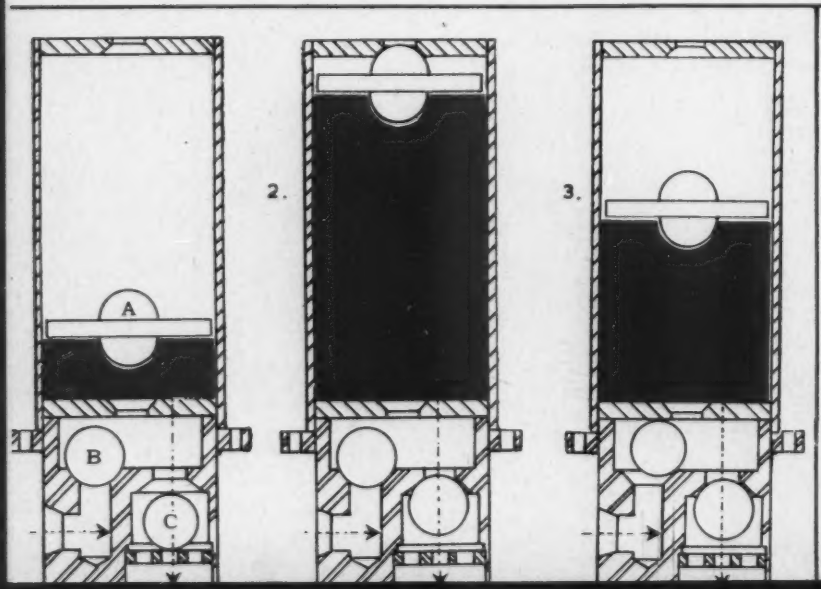
AN air-operated pump recently introduced by the Crossley Machine Co. of New Jersey works on a free-piston principle. It is claimed to be so simple in construction and operation that it can be operated indefinitely without losing its efficiency or being shut down. The pump has no moving parts such as a motor, drive shaft or belt, packing or seals, and requires no lubrication. It is claimed to provide 100 per cent efficient positive displacement of any substance that will flow, and is stated to be suitable for pumping any liquids from molten metals (up to 1,100 deg. C.) to ice cream, including abrasives, concrete, milk, greases, medicines, ceramic slip and water.

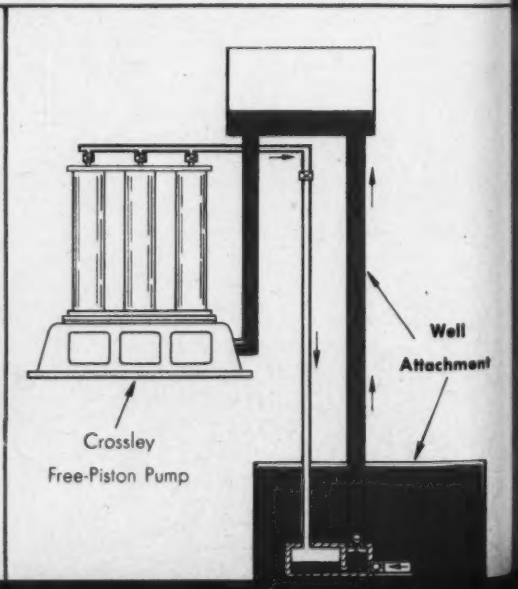
The operational principle is illustrated by the three sectional sketches, which represent the three cylinders with which the pump is provided. The chambers are of stainless steel, the base and jacket being of alloy cast iron. The free-floating piston and ball check valves in each chamber are of hard nylon (for normal temperatures), appropriate pistons and valves being substituted if molten metals are to be pumped.

Filling and discharge of the chambers is automatically actuated by the electric control box, which can be installed at any distance from the pump.

Standard models will have capacities ranging from 5-1,000 gal./min., and using air at 100 p.s.i. will, it is claimed, provide a head of water 220 ft. high. Lower or higher air pressures can, however, be used, ranging from 10-1,000 p.s.i.

Rate of flow is governed by the size of pipe, inlet and outlet, the various orifices and the input pressure. When used for pumping wells, the air forces the fluid up into an overhead tank, whence it flows down into the pump.





Valves for Controlling Flow-rate and Excess Flow

THE diagrammatic drawing illustrates the working principle of two valves which have been developed by Simmonds Aerocessories Ltd. to:

(a) limit the flow-rate of a liquid stream to a predetermined rate of flow per minute; and

(b) shut off the stream at a given rate of flow.

The only difference between the two valves is the presence of the latch mechanism in the excess flow valve.

The flow-rate control valve operates as follows:

A pressure differential developed across the main orifice plate is signalled via the lines (A) and (B) to opposite sides of the diaphragm (C) in the control pilot valve. The high-pressure line (A) is connected to the underside of this diaphragm.

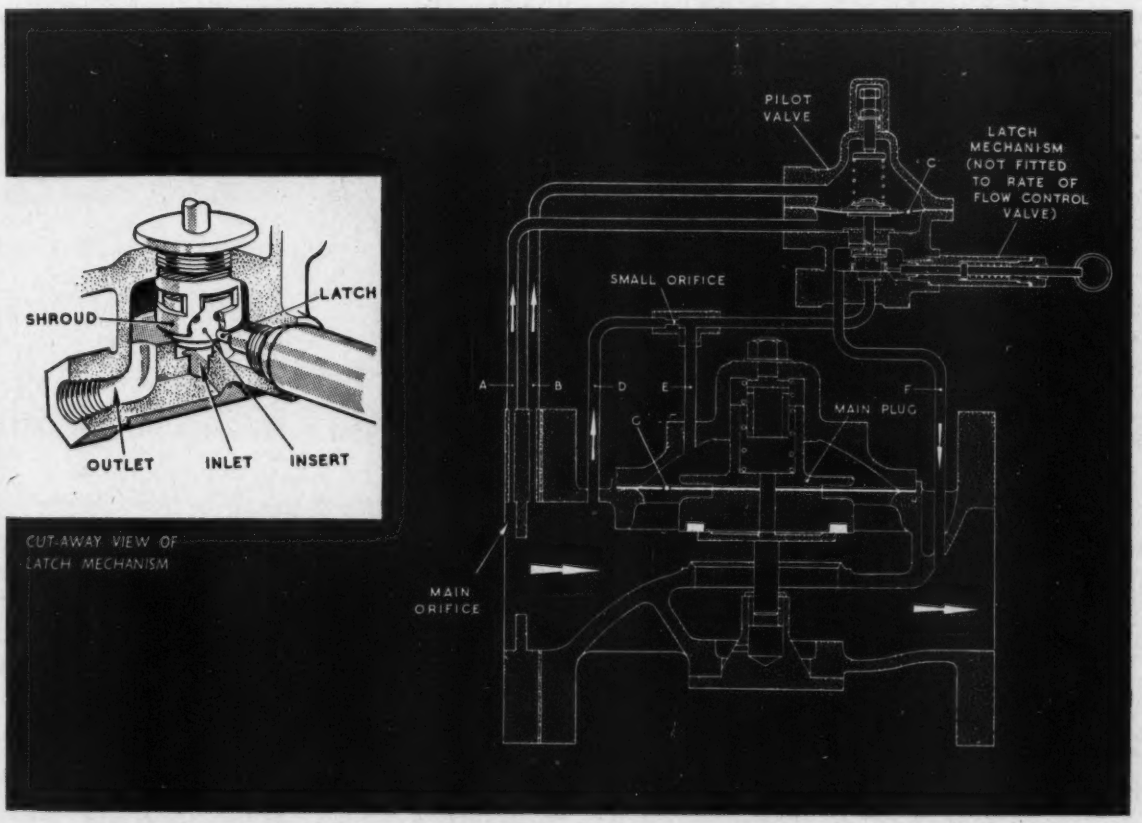
Under normal flow conditions, the action of the differential pressure on diaphragm (C) maintains this valve in an open position. Simultaneously, a small quantity of liquid in line (D) by-passes the main plug upper chamber, partially evacuating this chamber via line (E) to effect a pressure drop across the small orifice: this flow continues downstream of the main valve via the pilot valve opening and line (F). As the initial flow-rate continues, therefore, the main plug remains open to permit liquid flow at the predetermined rate.

Conversely, an increase in the initial flow-rate increases the pressure differential across the main orifice to effect closure of the pilot valve. This reduces the pressure drop across the small orifice in line (D) and increases the pressure over the top surface of the main diaphragm (G), effectively limiting the main plug opening. Under actual working conditions, a balance is achieved to maintain the correct discharge rate of flow.

In the case of the excess flow shut-off valve, a differential occurs at the point where the pilot valve is caused to close, following an increase in the initial flow in excess of the given rate.

In valves for this type of duty a spring-loaded latch mechanism (as illustrated), fitted to the pilot valve, is forced by a compression spring against the pilot valve shroud (see inset drawing). Movement of diaphragm (C) lifts the shroud to the closed position and permits further entry of the latch underneath the shroud towards the valve insert, thus locking the shroud in the closed position, i.e., over the outlet ports of the valve insert. This causes an increase of pressure over the main diaphragm, as above, to effect positive closure of the main valve and cessation of flow until normal conditions are restored and the latch is manually reset.

Both types of valve are made in bore sizes of 4 in. and 6 in., the end flanges being drilled to American standard ASA.B.16.5. The valve bodies are tested at 250 p.s.i. and are of cast aluminium alloy, the valve stems and shroud being of non-magnetic stainless steel. Both types of valve are set, during manufacture, to a specified rate of flow within an overall range of 100-800 Imp. gal./min. and are said to be suitable for use in temperatures up to 75 deg. C.



DESIGNING FOR SIMPLER METAL FINISHING TECHNIQUES

Polishing, plating and painting of components can be needlessly complicated by the designer failing to understand the limitations of the various processes. This article discusses some of the pitfalls that can be avoided

by ADRIAN WALMSLEY*

ONE of the most important factors affecting the finishing of metals is really the design stage of the component. Indeed, it is one of the ever-recurring problems of a metal finisher when presented with a particularly difficult object to polish, plate or paint that he was not consulted about the design which would have enabled him to offer alternatives for considerably simplifying his task, cheapening the process and, at the same time, producing a shape more streamlined for sales appeal, and without in any way affecting its function.

To help understand this attitude, the designer should therefore be able to appreciate the limitations and potentialities of finishing techniques.

Polishing

For decorative finishes, the initial process is most likely to be a polishing operation. This can be done by hand, by automatic machine or by a combination of both methods.

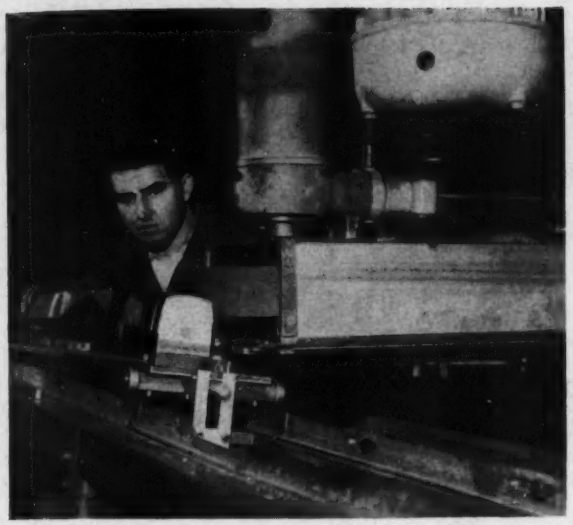
The objects are progressively smoothed, using graded abrasives either on linishing bands or on felt "bobs" prepared by the polisher himself. These bobs and the cloth mops used in the final polishing are usually about 1 in. or 2 in. thick and 10 in. or 12 in. in diameter, although the range of diameter can vary from 1-22 in. In use, the diameter decreases with wear. Below about 6 in. in diameter, the peripheral speed has dropped so much (most polishing machines being of constant speed) that economical polishing is no longer possible; the designer should thus keep in mind that a surface to be polished in this way should be such that it can be touched by a wheel of 6-12 in. diameter. As this operation is the most costly of the finishing operations, the area, the shape and the surface condition of the metal all affect the time taken, and hence the cost. Area should thus be as small as possible and surface condition as good as possible. Here, accidental damage such as scratches, etc., from careless handling in previous operations can be extremely difficult to remove; in general, the softer the metal, the easier the polishing. However, these softer metals, particularly zinc and aluminium alloys, are chemically active metals and require special plating techniques, with relatively thick coats of copper, nickel and chromium to give complete protection, which may offset any saving in polishing costs. The intended environment of the finished component also has a bearing on the base metal and its finish: zinc-base alloys are more suitable for indoor use with moderate corrosive atmospheres; brass and other copper alloys are excellent materials for polishing and plating and their corrosion resistance is good (advantages worth weighing against rejection of these materials on the grounds of cost).

BARREL RUMBLING—A further method of polishing, used especially for very large production on relatively small articles, is by barrel rumbling. In this process the articles are loaded into a many-sided barrel, which is rubber lined on the inside, and can be revolved about its axis or even eccentrically, preferably at variable speeds, with abrasive chips or polishing media and a prescribed volume of water with other chemicals. The time of treatment is usually several hours, so that the main consideration in design is that the parts should be sufficiently robust to withstand deformation by the weight of material being rumbled.

Screwed portions or other parts which are not to be polished may be protected with rubber or plastics caps or even held in fixtures in such a way that the abrasive media act only on the areas requiring polishing. Even large articles, machined to very fine limits and weighing many pounds, may now be finished by these special jigging methods.

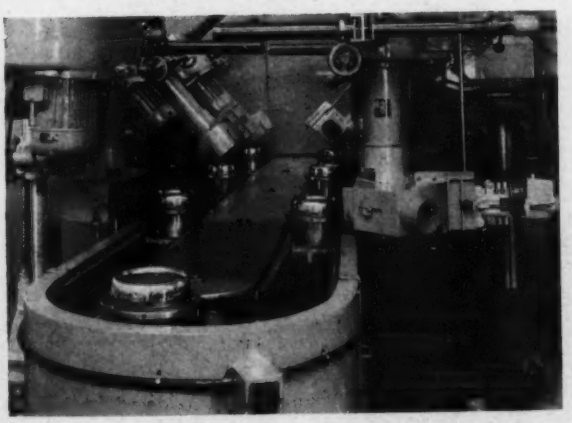
ELECTRO-CHEMICAL POLISHING—Quite recently, chemical and electro-chemical polishing has been developed to a sufficiently high standard to merit its consideration in

* *Chairman, N.W. branch, Institute of Metal Finishing.*



Preliminary linishing of a car bumper on a Silvercrown "straight-through"-type polishing machine.

Several small plating barrels used for electroplating components for Marconi's Wireless Telegraph Co.



Automatic-return-type polishing machine, fitted with six adjustable polishing heads.

industrial finishing. Its use is as yet almost confined to the treatment of stainless steel and aluminium, and, while there is little restriction on the design, the material used in manufacture must be very strictly controlled, as the chemical solutions must be carefully matched to the alloy in each case. It is unusual to find parts made from two even fairly similar alloys being treated in the same solution. The initial chemical equipment is costly, but production costs are fairly low, and even most intricate shapes can be polished to a degree virtually impossible by other means.

However, too much stress cannot be laid on the fact that the co-operation of the designer and the finisher should start at the first conception of the idea, for especially in the case of aluminium and its alloys, some brightening treatments are only possible on a small range of alloys, even to "super-purity" material of 99·9 per cent aluminium, with a possibility of up to 1·5 per cent magnesium. As such alloys do not possess the desired physical properties required for many applications, their use is obviously limited.

Electroplating

Turning now to those considerations of design and materials affecting electro-plating, the first general thought should be that of actual physical size. At the upper end, while local conditions vary, plating vats are usually not longer than 6 ft., with an effective width and depth of 2 ft. Very large articles should therefore be so designed that they may be split to fit such tanks and assembled after finishing. They should preferably be of such a weight that they may be comfortably handled by one man.

In the actual plating solution the most important factors are the strength of the solution, its temperature, acidity (or alkalinity), purity, degree of agitation and the correct proportion of its component parts. Metal anodes are suspended in the solution, connected to a positive d.c. supply, and these, as well as carrying current into the solution, usually replenish the metal content of the solution. The article to be plated is connected to the negative d.c. source and the correct voltage and current density for the size of that article in that particular solution are applied. The thickness or the total weight of metal deposited depends on the current passed and the duration of time.

Unfortunately, the metal is not deposited evenly except on the simplest of uniform shapes, but builds up more quickly on those areas nearer to the anode, and which thus have a higher current density. Thus promontories become more pronounced and recessed portions may receive no deposit at all.

In the design for best protection afforded by uniformly distributed metal, it is better to avoid sharp edges, re-entrant angles (especially acute ones) and similar forms; luckily, these shapes coincide fairly well with requirements for polishing. The effects of this trouble are more serious with some metals than with others (the plater calls this "throwing power"), but the plater himself can influence the result to some extent. Fig. 3 shows how the deposit on a simple cube can be varied by the method of suspension in the solution, and Fig. 4 shows that, by using auxiliary anodes and cathodes, current can either be introduced into, or led away from, various points so that uniform plating is obtained. Obviously, such auxiliary anodes require very careful positioning. As most plating solutions are dense, opaque liquids, it is not possible to watch what is happening while the plating is occurring, so that quite elaborate and rigid fixtures must be employed. Fig. 6 shows how a slight modification in design, admittedly requiring an extra operation, could be adopted with a threaded hole to provide sufficient clearance for normal plating build-up without interference; such forethought can save a great deal of trouble and recrimination later, especially in cases where trouble with "fit" may be anticipated.

Screwed threads are particular cases where conventional

plating methods very often cause trouble, as Fig. 5 shows. Small screws are usually plated in barrels, where the tumbling action of the barrel itself may even cause burrs on the threads, accentuating the trouble caused by the uneven build-up of metal; due allowance should be provided for this.

Types of Plating

In deciding on the nature and thickness of a protective finish for an article, the following brief details of the commoner processes available has been grouped into several parts according to the degree of protection afforded:

OXIDE, PHOSPHATE AND SIMILAR CHEMICAL FILMS—These, in general, do not give much protection in themselves, but form a base or key for other films such as oil, lacquer or paint. They are quite thin (almost immeasurable) in themselves, but may be coloured. Gunmetal black is a good example of this class.

OXIDISED FINISHES—These include oxidised coppers, brasses and bronzes, oxidised silver, etc. They are produced by plating usually cheaper metals with a thin film (about 0·0002 in.) of usually copper or silver, oxidising this chemically, relieving this oxide film to produce the familiar pleasing effects and again coating with a clear lacquer. Here also the degree of protection is afforded by the choice of lacquer.

BRIGHT CORROSION-RESISTANT FINISHES—For decorative finishes, bright chromium, nickel, alloy plating such as speculum, brass or bronze, are all eligible. If properly carried out, permanently bright deposits can give many years' protection in the environment for which they are intended. In bright chromium plate, the protection is given not by the chromium itself but by the undercoat of nickel or of copper and nickel. It is invariably the thickness of this undercoat and its freedom from porosity and microscopic cracks which determines the quality of the chromium, and in this, and other cases to be discussed later, specifications governing this aspect of quality should be laid down.

Where appearance of the deposit is not the primary consideration, deposits such as cadmium, zinc, tin and alloys, such as tin-zinc and tin-nickel, are used, although most of these metals can be deposited "bright" and are quite attractive. They can offer good resistance to corrosion in their particular environment with or without extra protection afforded by additional treatments such as passivating (which may leave a not-particularly-pleasant khaki colour) or painting. Little consideration in design is needed for such treatments, apart from a knowledge of some of the features of the metals concerned. For instance, cadmium should not be specified on parts likely to come into contact with foodstuffs: nickel or tin or even silver should be chosen in these cases. Springs and other parts made of steel with a tensile strength of over 45 t.s.i. should be stress-relieved after plating. As the plater is not likely to know the tensile strength of any metal submitted for plating, special arrangements should be made to give him this information.

"INDUSTRIAL" PLATING—This includes heavy deposits of chromium, nickel, iron, silver, etc. Although the expression "hard chromium" is often used, this term is actually a misnomer, for the chromium is virtually of the same hardness as that in bright chromium. The difference is essentially one of thickness, and, of course, "hard" chromium has no undercoat of nickel. It is usual in preparing components for a heavy build-up of metal, i.e., anything from 0·001-0·030 in. or more (e.g., for reclamation of valuable parts badly worn in service, salvaging of under-machined components, or to give certain new parts special wearing properties), to carefully grind the area to be plated in such a way as not to form microscopic cracks which are accentuated in plating, and to radius all angles. As it is only possible to deposit most metals smoothly up to about 0·003 in. thick, it is usual practice for thicknesses above this to plate at least 0·002 in. oversize and then carefully grind back to the correct size. Areas not requiring plating can, of course, be "stopped off" by the plater using an inert non-conductor such as wax, paint or plastics or rubber caps or tapes.

PRECIOUS METAL PLATING—As well as for purely decorative application in the jewellery and allied trades, there is an increasing use of precious metals such as silver, gold, platinum, rhodium and indium in the electrical industry especially for the tarnish resistance offered by these metals in preserving electrical contacts. Mainly because of price and also because these films are fairly soft, the thickness is usually not more than about 0·0001 in.

Treatment of Aluminium

Although by using special techniques aluminium can be plated with any other metal, the protection afforded is not yet as perfect as could be wished. This metal is protected mainly by anodising, i.e., making the article the anode in either dilute chromic or sulphuric acid solutions. The oxide film thus produced, being integral with the parent metal, has many desirable properties. With sulphuric acid anodising it is capable of absorbing organic dyes in the widest range of colours. When correctly sealed in pure boiling water, it is able to withstand a wide variety of corrosive conditions, provided that these are not strongly alkaline. Anodising by the chromic acid method, whilst providing a film equal in corrosion-resistant properties, does not produce as attractive a film as the sulphuric acid method. The dark brown stain of chromic acid weeping from any minor surface imperfections does, however, make it useful as an inspection method, and the fact that any chromic acid trapped in welds or seams does not corrode the metal makes it the more favourable method of treating such fabrications. As no metal is deposited on to the aluminium, but rather the parent metal is converted to the oxide, an anodic film "grows" in thickness approximately equal to half the thickness of the film, as Fig. 7 shows. In normal cases, the film thickness will seldom reach 0·001 in., so that a micrometer reading before and after anodising would record this same figure. The exception is in the case of hard anodising, where, using refrigerated solutions kept down to about 0 deg. C., a thick, hard, brittle film up to 0·005 in. may be built up.

Protecting with Paint

Depending mainly on the method of applying the paint, whether by brush, spray, electro-static spray, by flow coating or by dipping, some consideration at the design stage would help the product. It should be remembered that it is practically impossible to apply paint of adequate thickness to the sheered edge of a sheet of metal. If it can be arranged, the raw edges should all be turned inwards. Holes, sharp depressions or promontories should also be avoided, as these can produce unsightly runs very difficult to avoid when dipping or flow coating is used. In these methods also it may even be necessary to include deliberate drain holes to allow excess paint to drain away correctly.

Specifications

Almost every metal finisher would prefer to work up to a specification rather than down to a price, and many specifications are available. These may be either process specifications or product specifications. In the former case all the steps in the process are carefully set out; in the latter, provided that the end product complies, the methods of achieving those results are left to the individual. These specifications may be issued by government departments covering items produced for a branch of the armed services, by large private firms for processes carried out in their own factories or by their sub-contractors and by independent organisations such as the British Standards Institution, whose recommendations may be found valuable in many cases as a basis for reference in forming contracts. Rigid inspection of a fixed percentage of samples should be insisted upon to ensure maintenance of the agreed standard.

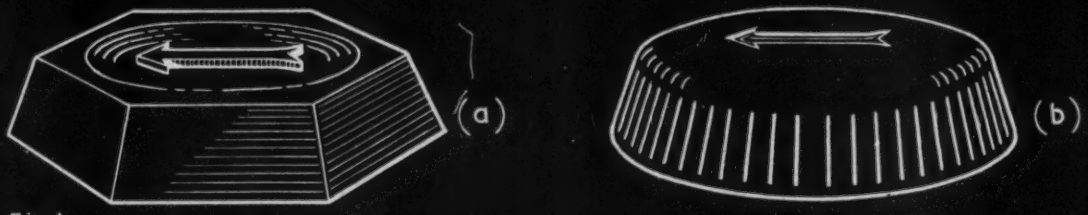


Fig. 1.

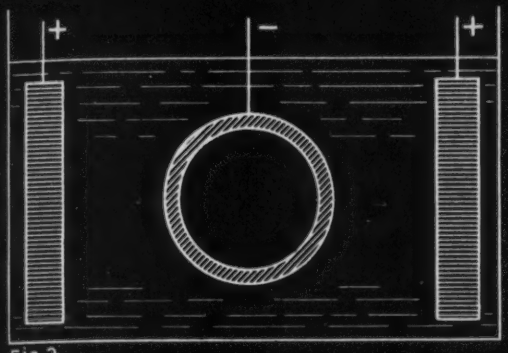


Fig. 2.

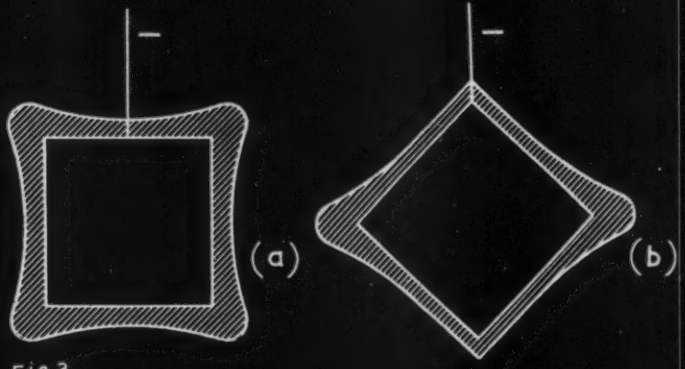


Fig. 3.

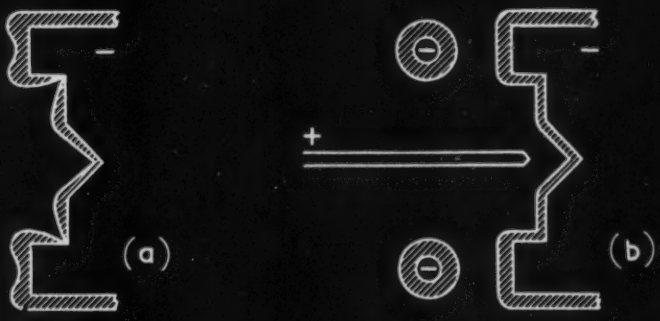


Fig. 4.

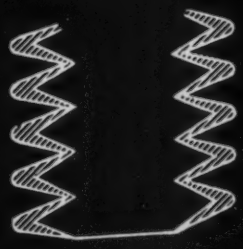


Fig. 5.

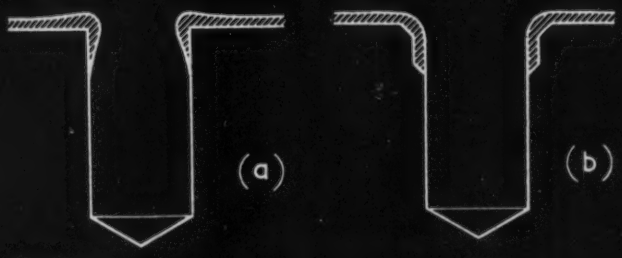


Fig. 6

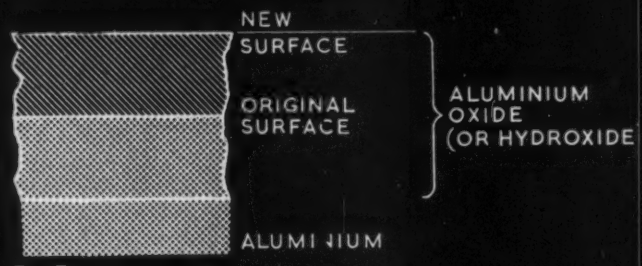


Fig. 7.

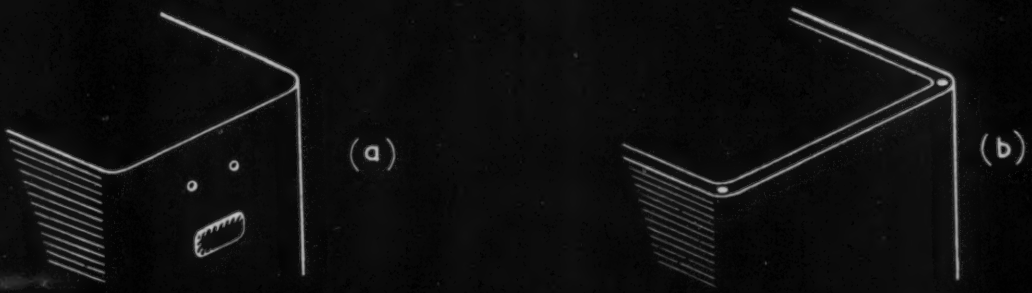


Fig. 8.

WHO'S WHO AT THE DESIGN CONFERENCE

Here is a quick reference guide to the principal speakers at the Engineering Materials and Design Conference at Earls Court from February 22-26:

Stainless Steels

J. I. MORLEY, A.Met. (Sheffield), F.I.M.

was born in Sheffield in 1917. He was employed by Thos. Firth & John Brown Ltd. from 1933-39 and, while studying at Sheffield University, was awarded an associateship in metallurgy in 1937. He rejoined the Brown-Firth Research Laboratories in 1945 and began to specialise in stainless and heat-resisting steels, having several research papers published. In 1957 he was appointed chief metallurgist and special director of Firth-Vickers Stainless Steels Ltd.

Designing for Safety

B. SHACKEL, M.A.

is research and engineering psychologist at E.M.I. Electronics Ltd., where he is responsible for advising the engineering design teams on all ergonomic aspects of their work. E.M.I. equipment to which his department has contributed include the recent oscilloscopes and computers, such as the large EMIDEC 2400. Mr. Shackel read psychology at Cambridge before becoming a member of the Medical Research Council's applied psychology research unit in 1952. He joined E.M.I. in 1954.

High-pressure Hydraulics

D. E. TURNBULL, Ph.D., B.Sc. (Eng.)

served a five-year apprenticeship at the Royal Aircraft Establishment and graduated with first-class honours from London University in 1951. He spent three years at Pembroke College, Cambridge, carrying out research on hydraulic servo-mechanisms and was awarded his Ph.D. in 1956. After spending a year at the English Electric Co., he joined the British Hydromechanics Research Association. He has recently returned from a tour of the U.S.A., where he studied developments in hydraulics.

High-pressure Hydraulics

H. S. STEPHENS

was born and educated in Vienna and spent ten years as detail and later design draughtsman on pumps and contractors' plant with Millars Machinery Co. Ltd. He joined the British Hydrodynamics Research Association in 1952 as a research assistant and obtained his H.N.C. with distinctions in mechanical engineering at the S.W. Essex Technical College in 1957. He is now head of the information department of the B.H.R.A.

He will be joint speaker with Dr. D. E. Turnbull.

Beryllium

A. J. MARTIN, B.Sc., Ph.D.

is 31. He graduated with first-class honours from London University in 1949, and completed post-graduate studies into the stress-corrosion characteristics of high-strength aluminium alloys at the Royal School of Mines in 1952. On joining the A.W.R.E., Aldermaston, he worked for five years on vacuum distillation, zone refining and thermal analysis studies of beryllium, and is now in charge of the beryllium section which deals with the development of casting, powder metallurgy and fabrication.

Magnesium Alloys

P. A. FISHER

was born in Birmingham and studied at Central Technical College, being subsequently awarded the City and Guilds Institute Silver Medal in non-ferrous metallurgy. He was with I.C.I. (Metals) Ltd. for a number of years before joining Magnesium Elektron Ltd. in 1939 and subsequently becoming foundries manager at the M.A.P. Lowerhouse factory. Since transferring to research and development in 1945, he has been closely associated with the development of magnesium-zirconium alloys.

Pumps for the Processing Industries

J. O. S. MACDONALD, B.Sc., A.R.I.C., A.M.I.Chem.E.

has had wide experience in both the chemical and chemical plant industries, both on the design and operation side. He worked as a plant manager at the Magnesium Elektron factories at Clifton Junction and Lowerhouse, Lancs., during the war years, and after the war joined Fraser & Fraser Ltd. as a chemical engineer. He spent several years with British Oxygen Research & Development Ltd. and Murphy Chemical Co. Ltd. He is now editor of the technical journal, *British Chemical Engineering*.

Rubber in Engineering

A. N. GENT, Ph.D., A.Inst.P., A.I.R.I.

is a principal physicist of the British Rubber Producers' Research Association. He has studied the mechanical behaviour of rubbers under large deformations, under alternating forces, and at extreme temperatures, and the results of these investigations have been published in numerous papers. In addition to research work, he now leads a technical advisory section concerned with new engineering uses of rubber, and has advised on the design of rail sleeper pads, mountings for road bridges and problems in vibration isolation.

Vacuum Melted Materials

H. C. CHILD, B.Sc.

was educated at Glasgow University and Royal Technical College, Glasgow, where he obtained a B.Sc. in metallurgy. He joined Jessop-Saville Ltd. in 1945 and is now that company's research manager. He has been concerned with the development of high-temperature materials, including steels, nickel and cobalt-base alloys, and with the associated problems of creep and corrosion.

Since 1952 he has been engaged in the development of processes for titanium production and associated alloy development studies. His work has also involved a study of the vacuum melting process for steels and other alloys, leading to production facilities for both vacuum induction and vacuum arc melting.

Standards in Design

R. K. WHITEHEAD

is standards engineer at the Stafford works of the English Electric Co. He studied electrical and mechanical engineering at Oldham Technical College, served an apprenticeship with Ferranti Ltd. (Hollinwood), and obtained experience in the transformer works and in the jig and tool design department, before becoming a design draughtsman. He joined English Electric in 1936 and was chief draughtsman of the meter division from 1939-50. He moved to the central standards section in 1951 and has, since 1954, been responsible for standardisation at the Stafford works.

The Case for Industrial Design

H. A. NIEBOER, A.M.I.Mech.E.

was born in Holland and trained as a mechanical engineer. He began his career as a resident engineer at a sugar mill in Java, but after travelling extensively in Europe he went to South Africa and practised as a free-lance industrial designer. There he obtained British nationality. He moved to the U.K. just before the war and in the following years lectured to the armed forces on political and economic matters concerned with the war effort. He has since resumed his practice in England as a general industrial designer.

Reinforced Plastics

A. W. THOMPSON, B.Sc., A.F.R.Ae.S.

is deputy to the chief development engineer (plastics) of Bristol Aircraft Ltd. He was educated at Christ's Hospital, Horsham, and was apprenticed to the Bristol Aeroplane Co. before joining the Royal Air Force and completing his national service. He graduated in aeronautical engineering at Bristol in 1949. He worked initially on general aircraft design, and later transferred to project design and, in 1952, began to specialise in the design of reinforced plastics structures.

Plastics for High Temperatures

V. E. YARSLEY, M.Sc., D.Sc. (Tech.), F.R.I.C., F.P.I., M.I.Chem.E., Hon.A.C.T. (Birm.)

is founder and managing director of Yarsley Research Laboratories Ltd. and Yarsley Testing Laboratories Ltd., and has been associated with the plastics industry for thirty-three years. He spent several years in industry in the manufacture of cellulose acetate and photographic base film, before starting practice as an independent consultant in 1931, specialising in cellulose ester plastics. He has since sponsored research and development in high polymers and related materials. He is a past president of the Plastics Institute and was chairman of its education committee for twenty years, as well as currently being a member of various educational bodies.

Centrifugal Castings

I. L. GWYNN, L.I.M., A.C.T.S. (Birm.)

is a director of P.I. Castings (Altrincham) Ltd. He began his engineering career as an apprentice metallurgist with the Deritend Stamping Co. and was subsequently appointed assistant to the chief metallurgist. In 1947 he joined the David Brown Foundries Co. for development work relating to the investment casting foundry and was later appointed superintendent of the pilot plant. He took up the position of works manager of the newly-formed P.I. Castings in 1950, and is now a member of the board, responsible for technical matters and sales.

Industrial Design in Engineering

R. M. S. KAY, B.Sc. (Tech.), D.A.A., F.R.S.A.

was trained at Manchester University in electrical engineering, specialising in electronics design. He had two years' practical training with Metropolitan-Vickers Electrical Co. Ltd., and later moved to the organisation's publicity department, where he was to specialise in display and promotion films. During the war he was a signals officer in the R.A.F. for six years. In 1949 he helped to establish an appearance design committee, of which he was appointed secretary; he was appointed full-time industrial design engineer three years later.

OTHER MAIN SESSIONS

Other speakers who will be delivering papers during the conference are: H. Morrogh, director of the British Cast Iron Research Association, who will speak on "The Design of Castings"; J. Shapiro, Dipl.Ing., A.M.I.Mech.E., A.F.R.Ae.S. (a design consultant), on "Design Trends in Germany"; C. Snell, M.Sc. (University College, London), on the "Uses of Photoelasticity"; E. T. Jagger, B.Sc. (Eng)., Ph.D. (Geo. Angus & Co.), on "Seals"; and D. Firth (National Engineering Laboratory) on recent developments of "Fluid Power".

Applications for tickets for the conference should now be made without delay to the Secretary, E.M. & D. Conference, Drury House, Russell Street, London, W.C.2.

designer's notebook

A Pre-selective Conveyor System

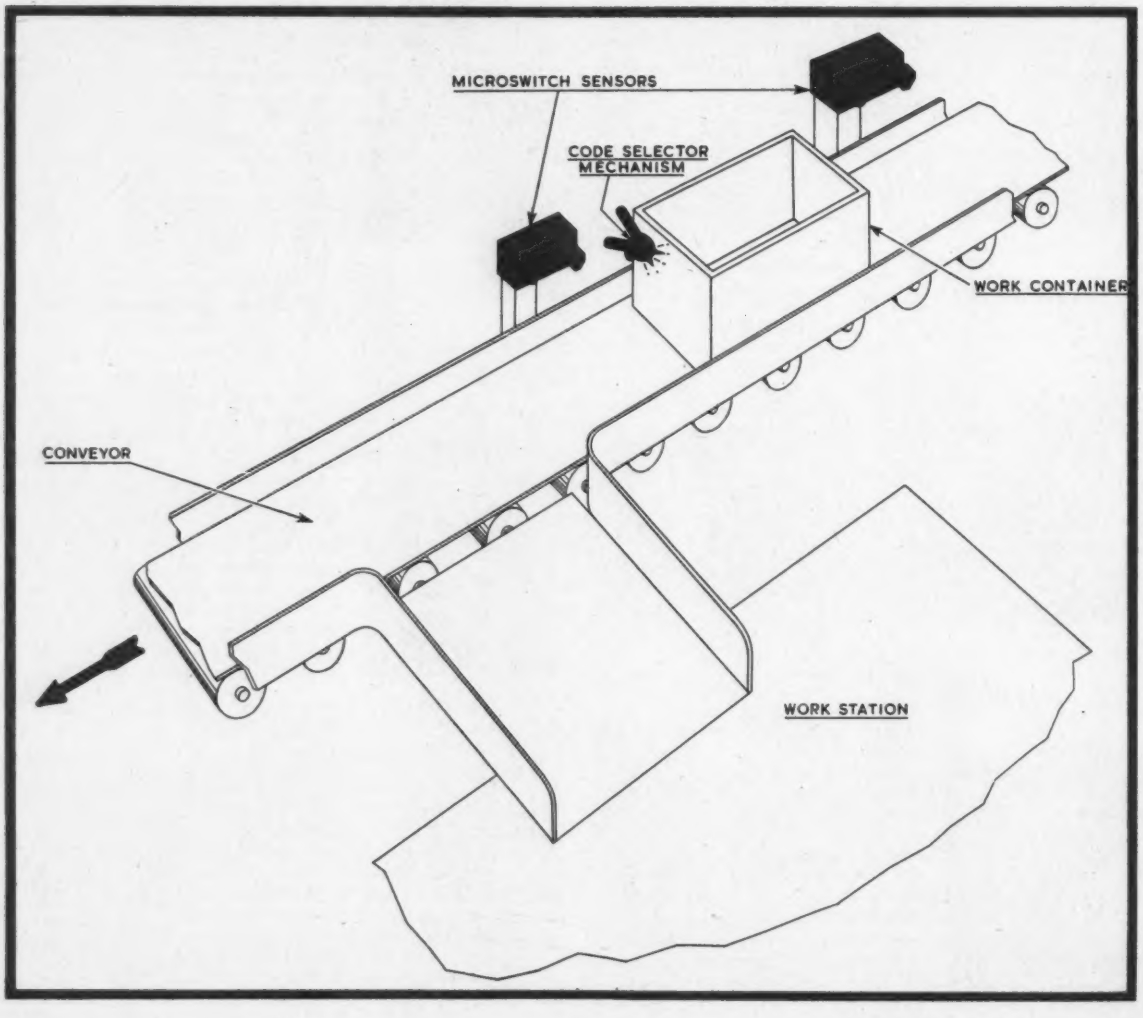
LINE production of identical products is a simple matter compared with the problems that arise when a large number of different models or sizes of a product is to be produced. Batch production does not lend itself easily to line-production methods.

The diagrammatic drawing illustrates a flexible system known as Automa, whereby batch delivery of materials or components can be made to any locations in a predetermined sequence or at the discretion of the operator.

The work containers have mounted on them at one corner a simple selector mechanism on which a code is set. The settings are detected by sensor switches, located on the sides of the conveyor, and the work containers are presented to each switch for recognition of the code. Should a coincidence of the code and the sensor occur, an actuator is placed in the intercepting position, but should no coincidence occur, or should the operation of the interceptor be inhibited, the work container will pass on its travel along the conveyor without interruption. The interception occurs at the base of the container. A turning motion swings the container, at slow speed, to an adjacent receiving table or to another conveyor travelling in another direction.

When the operator has completed the work in the container, using appropriate routing instructions, he can reset the selector mechanism to a new code and re-load the container to the conveyor on its way to the next selected station. When more than one operator is performing similar operations, the stations can be arranged not to accept all work, but to spread it evenly, or conditionally over the whole of similar operations.

The mechanism shown is electro-mechanical, but different types of signalling can be employed. Using two sensors and, say, ten alternative positions for each part of the detecting device, it will be seen that a very large number of alternative routing instructions are possible.



Shaft Values and Accumulative Backlash

IT has been said that a healthy appreciation of what are known as shaft values is the beginning of design wisdom. It could be added that their neglect is usually the end of it.

One turn of each rotating member of a mechanism has a certain value in whatever units are involved. The training rack of a gun mounting, for example, has a value of 360 deg. per turn; the training motor may have a value of one or two degrees per turn, and the intermediate shafts will have intermediate values. Shaft values may be in units of deflection, yards, seconds of time, or any other units with which the gear deals. Sliding members, such as racks, will have corresponding values of numbers of units per inch of travel. These values should be clearly marked on the actual part, on all arrangement drawings (not only on the gear diagrams), and also more especially on all pictorial drawings or handbook illustrations. They are the only means of assessing whether the detail construction shown is likely to be adequate for the performance required, and of following and analysing the operation of the gear in every detail.

In addition to the value of one turn of each part, there will also be a value per unit (say, 0·001 in.) of free motion (backlash) between each pair of parts which are supposed to be in contact, e.g., meshing gear teeth, or dogs in a clutch. This is easily reckoned from the value per turn and the radius of the point of contact which takes the drive.

All gear trains should be reasonably graded, i.e., gearing up and then down again, or vice versa, should be avoided like the plague; shafts, gears, bearings and their supports, etc., should be well adapted for their working conditions and loads, and there should be no pronounced point of weakness, e.g., undue backlash or spring at any particular point.

To bring out these factors more vividly we used to make a chart of each gear train on the lines shown in Fig. 1. Each vertical column represents an element of the gear train and each vertical line represents the point of contact between two successive elements. The full line referred to in the right-hand scale gives the shaft value of each successive element. The dotted line referred to in the left-hand scale gives the value, in the units used, of, say, 0·001 in. of linear backlash at the driving point between two successive elements.

There is no objection to big jumps in successive shaft values. A single gear ratio of 20:1 may be much better, if it can be accommodated, than a series of gears giving the same overall ratio; but the jumps should, as far as possible, all go the same way. The criterion of excellence in a gear train is usually a stiff and narrow mechanical hysteresis loop; this is best ensured by gearing up (or down) all the way. The usual 2:1 ratio inherent in a differential gear should be used as a part of the general trend. In awkward cases the performance may be spoilt if the inherent 2:1 is used the wrong way so that an additional 2:1 or more up, either before or after, has to be introduced.

If, on the chart, shaft values are jumping about, up and down, regard it as a human temperature chart and look out for trouble. It is worth almost any effort of redesign to get the shaft values flowing reasonably smoothly. Complications may arise in gear trains involving differential gears, where the full line branches out into two, which perhaps rejoin later, but the principle of grading of values is simple and can easily be followed. Grading of sizes and strengths to suit the gear ratios may also be a pitfall if the few simple and obvious rules of load, tooth size and face width are not followed.

Worm gears should generally be avoided, as they

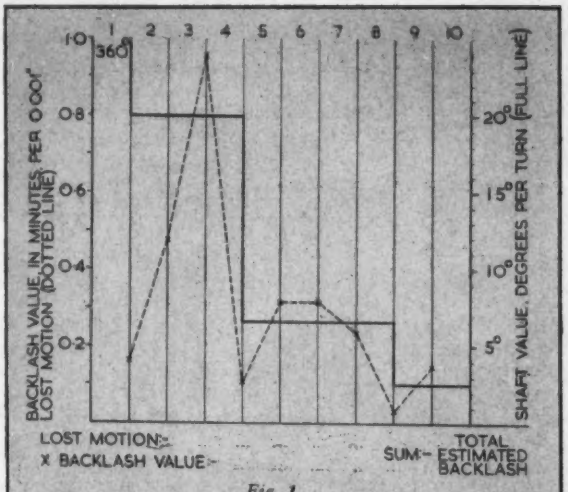


Fig. 1.

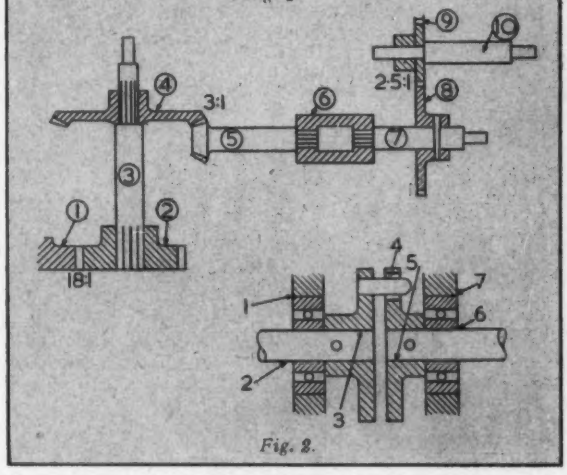


Fig. 2.

always give much wider hysteresis loops than spur gears, except in cases where this effect is not material, or where there are special reasons for adopting a worm gear.

Under each vertical line on the chart can be put a figure of the estimated backlash under load at this point in thousandths of an inch, allowing for the type of workmanship expected. This figure, multiplied by the figure of units per thou. backlash (dotted line), will give us an estimated backlash value at this point. These figures, added up horizontally over fifty or a hundred columns, will give an overall theoretical estimate of backlash in the gear train. All these backlash values per thou. of clearance should be kept small. If the design is not closely watched, some of these values, e.g., a small-diameter splined shaft with a high value, may turn out very large. The point of the chart is that these high backlash values stand out vividly, and call attention to where more care is needed.

Several successive elements may have the same angular value. The backlash value per thou. between such successive elements, however, may be very different. The degree to which separate elements need to be shown is a matter of judgment; a single pin clutch, for example, as in Fig. 2, has no less than seven points at which backlash may develop, though if good workmanship can be relied on it may not be necessary to deal with more than one on the chart. A little experience will soon tell.

H. Clausen, O.B.E., I.S.O., B.Sc. (Eng.)

NEW USES FOR BERYLLIUM IN INDUSTRY

Machined aircraft instrument part of Berylco beryllium metal.

This is the first of a two-part series on beryllium's fabrication and application. Here the author discusses the metal's production processes and how these are likely to affect subsequent properties and some possible applications

by N. A. HILL, B.Sc.*

BERYL (beryllium aluminium silicate) is the only beryllium-bearing ore being mined commercially. The separated beryl contains 4-4½ per cent beryllium and the extraction of the pure metal is a long and costly operation. The beryl is first converted to beryllium oxide by a multi-stage chemical treatment; the subsequent reduction to metal has been accomplished by both thermal and electrolytic methods. In the thermal reduction method (used for large-scale production) beryllium oxide is converted to the fluoride which is then reduced to beryllium metal by fusion with magnesium. Vacuum melting ensures final purification. Electrolytic reduction has been effected on a fused eutectic of sodium and beryllium chlorides; purification of the deposited flake beryllium may be achieved by vacuum casting or by milling to powder and leaching in oxalic acid.

Primary Fabrication

Vacuum melting has superseded open pot melting as oxidation is reduced to a minimum (Gold calculated[1] that beryllium would oxidise in any vacuum down to 10^{-47} mm. of mercury) and the concentrations of volatile impurities such as magnesium or halogens are reduced. All risk of the spread of toxic fumes from the melt is avoided, but the high vapour pressure of beryllium means that some loss of metal is inevitable. The best crucible material is beryllia which, although brittle, may be expected to last for 10-30 melts. Investigators have stressed the importance of thorough de-gassing of all the mould components before use if porosity in the beryllium casting is to be avoided. Induction heating is used to melt the beryllium charge and the placing of a graphite sleeve around the crucible ensures that there is adequate and uniform heating. A recent paper by Ivanov and Shmelev[2] reports the successful application of centrifugal casting to beryllium, enabling very thin or complex sections to be run with ease.

All beryllium castings have a large grain size, and variations in the pouring temperature and cooling conditions may be used to produce very large grains, but the production of a fine-grain casting has not yet been achieved. The application of ultrasonic vibration during solidification

Deburring operation on precision-drilled beryllium components. (Brush Beryllium Co.)

* *Metallurgy division, A.E.R.E., Harwell.*

does not promote nucleation, but recently some reduction in grain size has been found in consumable electrode arc melted beryllium. Even this, however, is still very much larger than that of powder metallurgical beryllium. The occurrence of fine cracks in beryllium ingots has been reported, particularly when the diameter exceeds 6 in.; the addition of ¼ per cent of aluminium reduces the cracking, but the production of large crack-free ingots is extremely difficult. The large grain size in a material as brittle as beryllium serves to weaken the cast metal seriously and, although subsequent fabrication reduces the grain size, the mechanical properties of sections fabricated from cast billet are inferior to those fabricated from beryllium powder.

It is therefore unlikely that casting will be widely used as a primary fabrication process and its main application will be in the production of purified beryllium billets for reduction to powder. Casting may also be used to produce small parts or thin sections for use where mechanical properties are not important, and when the production of a piece of complex shape with a minimum of machining is desired.

Powder Production

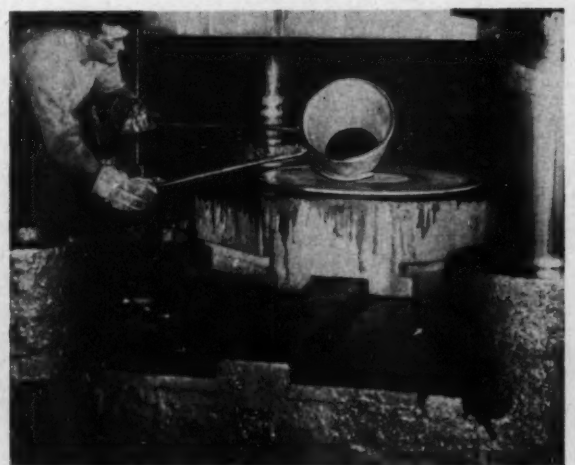
To overcome the disadvantages and limitations of cast beryllium, major research and development programmes have been devoted to the production and consolidation of beryllium powder. The Q.M.V. process[3] is used in the U.S.A. for large-scale production by the Brush Beryllium Co. Vacuum-cast billets are machined to swarf in an automatic lathe; the swarf is then ground to powder by a beryllium-faced attrition mill in an atmosphere of dry nitrogen, and the fraction below 200 mesh continuously drawn off. By careful blending of the powder lots, standard particle size distributions and oxide contents are maintained. In the U.K., two processes have been developed on a smaller scale. In the first of these,[4] electrolytic flake is ball milled to powder in a porcelain mill and the powder leached in aqueous oxalic acid to reduce the chlorine content; the second process[5] is identical to the Brush Q.M.V. process, with the exception that the swarf is powdered in a stainless-steel ball mill under argon. The chemical analyses of typical batches of the three types of powder are quoted in Table 1. Similar properties have been reported in products fabricated from the different powders, and it is shown later that the fabrication procedure may have a greater effect upon properties than the type of powder used. The high chlorine content of leached flake powder may cause porosity in fusion welding, but there has not been sufficient experimental work undertaken to offer conclusive evidence. Similarly, there is a suggestion that superior creep properties can be developed in rod extruded from oxalic acid leached powder.

Beryllium powder has been consolidated by sintering. Barrett, Ellis and Knight[5] have achieved densities of up to 1·81 gm./c.c. by heating loose powder in vacuum for 6 hr. at 1,220 deg. C., but for consistent results careful control of particle size is necessary. Prior cold compacting of powder at pressures of 50-80 t.s.i. is reported by Williams, Munro and Jones,[4] and Hausner and Pinto,[6] to enable densities of 1·84 gm./c.c. to be achieved by sintering for 5 hr. at 1,220 deg. C. Due to the high vapour pressure of beryllium at these temperatures, weight losses of up to 15 per cent occur during sintering and this, coupled with the associated shrinkage, has so far restricted sintering to laboratory production of solid beryllium where efficiency and dimensional accuracy are not of paramount importance. The precise control of powder packing and compacting necessary to ensure product consistency would be difficult to exercise outside a laboratory.

Large-scale consolidation has been developed by the Brush Beryllium Co. in the U.S.A. using vacuum hot pressing.[3] Expendable mild-steel moulds and plungers are used: the powder is loaded into the mould and the whole assembly is induction heated to 1,050 deg. C. under vacuum. The temperature is maintained for up to 4 hr. while a load of 75-150 p.s.i. is applied to the steel plunger. Blocks up to 6 ft. diameter and 1 ft. thick have been produced with a uniform density of 1·845 gm./c.c. Since the powder is enclosed in a die and the maximum temperature is 1,050 deg. C., metal losses due to evaporation are small and the maintenance of a good vacuum ensures a minimum of contamination. Pressure is applied throughout the operation, any gaps or discontinuities in the powder mass will be sealed during consolidation and the mould will be completely filled, so that accurate dimensional tolerances can be maintained. The result is a fine-grained homogeneous beryllium block which should be free from flaws and, provided the demand justifies the purchase of the relatively costly vacuum pressing chamber, this is a primary fabrication method which is unlikely to be superseded for some time in the future.

Experimental pressing over the range 400-1,100 deg. C.

Machining beryllium at the T.I. Technological Centre at Walsall. On the left is the multi-cyclone separator.



Large beryllium part forged on the bed of an 18,000-ton forging press at Wyman-Gordon U.S.A.F. plant.

TABLE I. Principal impurities in commercial beryllium

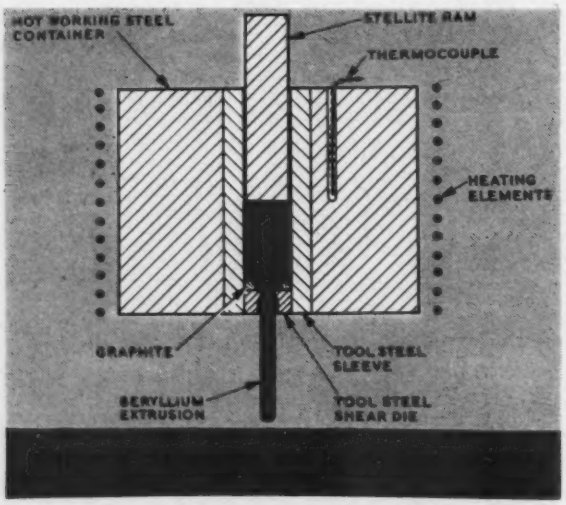
	Beryllium oxide %	Iron p.p.m.	Silicon p.p.m.	Aluminium p.p.m.	Halogens p.p.m.
Brush Q.M.V. powder[3]	0·7–1·0	1,100	800	400	20
Electrolytic flake, vacuum cast and powdered[5]	0·1–0·2	400	600	700	50
Electrolytic flake, powdered and leached in oxalic acid[4]	0·3	200–300	20	200	230

For references, see end of article.

by a variety of the techniques has been reported.[3, 7] Compacting in air is feasible even at 1,100 deg. C., provided that the plungers are a good fit and time at the pressing temperature is held to a minimum. Pressures to achieve full density vary from 100 t.s.i. at 450 deg. C. to 1,500 p.s.i. at 1,000 deg. C.; it has been found that higher pressures are necessary in air than in vacuo. Provided surface oxidation is not objectionable, hot pressing in air is an attractive laboratory process needing little complex equipment. Compacting in sheaths has also been used for experimental consolidation of beryllium powder. Beaver[5] filled thin mild-steel cans with beryllium powder, evacuated the can, and applied an external hydrostatic gas pressure of 300 p.s.i. The whole assembly was heated to 1,050 deg. C., when the gas pressure was sufficient to consolidate the beryllium. Tubing and more complex sections could be produced by this method and machined to finished dimensions. Williams[8] has reported the production of blocks and cylinders by the compacting in a die of a thin mild-steel can filled with beryllium powder, sealed under vacuum and heated to 1,000 deg. C. Folding of the steel can leads to surface faults, but this is minimised by cold compacting the powder and the use of thin-wall cans.

Rod and Tube Production

Experimental casting of rod and tube beryllium has been carried out, but the brittleness and large grain size of the cast products have led to the general use of extruded sections. Cast billets have been extruded at 800-1,050 deg. C. in presses used for brass or steel extrusion; cladding is necessary at these temperatures and mild steel has been proved most satisfactory.[9] Provided a lubricated flow is ensured during extrusion, the mild-steel sheath co-extrudes with the beryllium, preventing oxidation of the beryllium and attack on the extrusion die.



Extrusion of powder beryllium after prior cold or hot compacting has been used under similar conditions to produce beryllium rod and tube having a very fine grain size and excellent mechanical properties in the extrusion direction.[6, 9] Temperatures in the range 980-1,050 deg. C. have been found most suitable, and in the case of large billets of cold compacted powder the use of a hot precompacting stage or a penetrating ram to densify the beryllium avoids folding of the mild-steel can. Reduction ratios of up to 500:1 ($\frac{1}{16}$-in. rod from 4-in. billet) are recorded for rod and 50:1 (1 in. dia. × 17-gauge tube from 4-in. hollow billet) for tube extrusion at 1,050 deg. C. High ram speeds have been used, in the range 2-6 in./sec.

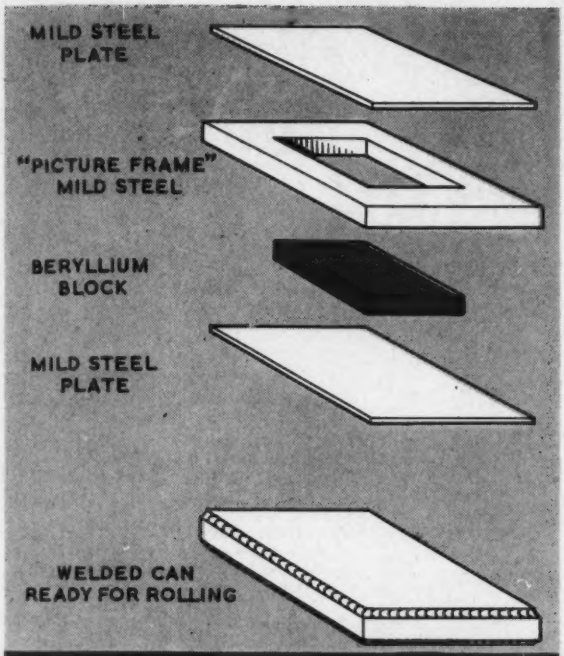
Bare extrusion of fully dense beryllium has been carried out in the temperature rage 400-750 deg. C. to produce short lengths of rod and tube without the necessity for expensive extrusion equipment. A typical set-up for extrusion[10] at 500 deg. C. on a laboratory frame press is illustrated below. The high extrusion constant (70,000 p.s.i.) limits maximum reductions in area to about 10:1; using a small billet $\frac{3}{4}$ in. diameter, it is possible to obtain reductions up to 6:1 in a 6-in.-diameter hot working steel container at 450-500 deg. C. Tool steel shear dies are commonly used with a graphite lead-in cone to ensure adequate lubrication. This process is ideal for laboratory production of rods up to 12 in. long and from 0·3-0·5 in. diameter. Recent reports indicate that rapid bare extrusion of fully dense beryllium in the range 500-700 deg. C. is possible using impact extrusion presses and dag or silver plate as lubricant. The production of rod and tube by these methods in the U.S.S.R. has been reported.[2, 11]

For the rapid fabrication of rods and other sections directly from powder, hot extrusion is an ideal method; however, the mild-steel can confers a poor surface finish and irregular dimensions, and subsequent machining is normally essential. A more suitable method of producing beryllium sections with good surfaces and close tolerances is likely to be rapid unsheathed extrusion of fully dense metal in the temperature range 500-800 deg. C. The production of billets by the well-tried method of vacuum hot pressing should ensure extrusions of consistent quality. Lubrication is likely to be a difficult problem, as complete separation of the beryllium from the die must be secured to prevent scoring.

Sheet Production and Working

Most of the fabrication development has been directed to the production of beryllium block and tube; only recently have proposals for aircraft use created interest in large-scale sheet fabrication. Laboratory investigations had established that sheet could be rolled successfully in mild-steel sheaths at 800-1,000 deg. C., using cast billet, extruded flat section bar, hot consolidated or cold compacted powder as starting materials.[12] It is necessary that the mild-steel cladding supports the sides of the beryllium during rolling, or severe edge cracking occurs; thus the "picture-frame" type of can shown on page 29 has been widely used. There are recent reports by Wikle[13] of successful bare finish rolling of sheet to give a good surface finish and close dimensional tolerances. At 600-700 deg. C., they found that it was possible to reduce the sheet 5-10 per cent before any cracking occurred.

Single crystal studies on beryllium showed that considerable ductility in tension at room temperature could be expected under stress parallel to the basal plane. Texture studies by Smigelskas and Barrett revealed that in certain beryllium sheet the basal planes tended to concentrate parallel to the sheet surface. Klein and co-workers[14] fabricated beryllium sheet by cross-rolling extruded flat



Cladding beryllium for rolling using a "picture frame" type of can.[8]

beryllium bar until the basal planes were parallel to the sheet surface. When this condition was reached, tensile tests on etched specimens revealed exceptionally high tensile elongation in all directions in the sheet plane. This is known as "two-way ductile" sheet and its properties will be discussed in a further article that will be published in the February issue.

As with extrusion, rolling of sheathed powder is a rapid and convenient way to produce fully dense sheet beryllium, but any variations in the packing conditions of the powder may cause variation in the sheet properties. The use of vacuum hot pressed block as a starting material should enable more consistent sheet to be produced, and it is likely that further developments of warm rolling in the range 400-700 deg. C. may render sheathing unnecessary, thus improving surface finish and reducing the expense of producing beryllium sheet. Sheets up to 30 in. in length have been produced, and any thickness down to 0·001 in. can be rolled; thus careful development of techniques should permit the production of large sheets (up to 6 ft. square) that may be obtained in any required thickness.

Successful cold working of sheet has not yet been achieved, and cold bend tests show an upper limit to the width of strip which can be deformed.[15] Attempts to bend strip above this limit result in brittle failure under complex stress at room temperature. All sheet, including "two-way ductile" sheet, fractures before any measurable deformation occurs. Warm working in the range 300-700 deg. C. is possible, provided tensile stresses are kept to a minimum, and the use of a deformable mild-steel support at 650 deg. C. has been recommended to make forming easier.[15]

Joining

The joining of beryllium to itself and other metals is still one of the major problems in fabrication and use of the metal, but, though difficulties remain, ingenious methods have been evolved in a variety of specific applications to avoid or solve the problem.

Fusion welding using vacuum as a protective atmosphere has been demonstrated, and heating the workpiece by electron beam was claimed to minimise grain growth and cracking during cooling.[16] However, some grain growth will occur, and the weld bead may be expected to have the low strength and brittleness encountered in cast metal. There has been no reported attempt at subsequent mechanical working to reduce these disadvantages in fusion-welded joints.

Limited evidence indicates that a low halogen content may be advantageous in beryllium used for fusion welding; but there has as yet been no large-scale use or appraisal of fusion welding, as the brittleness and low strength of the joints so far produced have been an effective deterrent.

Solid-phase bonding of beryllium has been reported using a variety of conditions. Livey and Williams[17] have recently reported the successful sealing of a plug into a beryllium tube by co-extrusion. A reduction of 4:1 in extrusion at 450 deg. C. using an extrusion pressure of 50 t.s.i. was sufficient to produce a very effective seal, and up to 4 per cent deformation of the tube was recorded before failure of the end seal occurred. Above 600 deg. C. a protective atmosphere is necessary to ensure good bonding, and upsetting two beryllium rods together in argon at 850 deg. C. under a pressure of 1½ t.s.i. is reported to give joints of ultimate tensile strength of up to 20 t.s.i.[8] The successful sheathing of metallic uranium in an envelope of fully dense beryllium has been reported[17]; the uranium was completely surrounded by cold compacted beryllium powder in a mild-steel can, and the whole assembly was heated to 1,000 deg. C. and forged rapidly under a pressure of 40 t.s.i. Under the proper conditions, complete welding of the beryllium powder gave a coherent 0·060-in. thick beryllium skin around the uranium which could withstand some deformation before failure. Diffusion bonding of clean beryllium surfaces has been reported when the surfaces are held at 1,200 deg. C. for 2 hr. in vacuum.[18]

Joining of beryllium to other metals has been achieved by brazing;[18] brittle intermetallic compounds are formed with most metals, the exceptions being aluminium and the element silicon. Wetting of beryllium with aluminium is accelerated by the use of a thin interlayer of magnesium. Silver or silver copper alloy has been used to braze beryllium to nickel, copper and a variety of steels. Brazed joints are satisfactory for use at low temperatures, but at elevated temperatures diffusion has been shown[19] to cause porosity in the beryllium after prolonged heating.

Finishing Treatments

There are, as yet, no cold finishing operations for beryllium. Effective cold drawing of rod and tube would be limited to almost negligible reductions before tensile fracture occurred. Unsheathed warm drawing in the range 400-600 deg. C. could be used to improve the surface finish and dimensional tolerances of hot extruded rod or tube. Warm extrusion in the range 400-600 deg. C. can give a good surface finish, provided care is taken to avoid pick-up on the die. However, the initial billet for warm extrusion must be machined to the correct shape and size.

Cold rolling of sheet has been reported,[12] but, as the material is so brittle, reductions of more than 1 or 2 per cent are impossible without cracking. Wikle, who has been currently reporting a programme of beryllium sheet rolling, has successfully warm finish-rolled 0·020-in. sheet unclad, and a 5-10 per cent reduction at 500-600 deg. C. was found to be of considerable benefit to the surface finish.

With the above exceptions, fine machining has been the normal finishing treatment for beryllium and it is only recently that quantitative data on the machining opera-

tions have been published. Walker[20] examined the machining process by high-speed photography and showed that chip formation during cutting occurs by a discontinuous stick-slip process up to 300 surface ft./min. Above this speed, chip formation is more of a continuous process and the surface finish of the work improves considerably. Walker also found that the depth of cut used has no detectable effect upon the amount of surface damage suffered by the beryllium. Provided machining is carried out at a sufficiently high speed, there appears to be little advantage in using light cuts. Carbide-tipped tools are normally used; a grade specified for machining a medium cast iron is suitable for beryllium, and tool wear is found to be comparable with use on mild steel.

Surface grinding is used for finishing flat sheets and blocks and an abrasive slitting wheel is most suitable for cutting sheet; milling must be carried out with care and the use of steel support is recommended to minimise chipping the beryllium.

The production of complex shapes to very fine limits is possible by careful machining, and because of the low density of beryllium, the use of complex fine-machined parts will increase in applications where weight must be kept to an absolute minimum and very close tolerances are necessary. Thus the use of machined beryllium in the inertial navigation system of rockets is reported[21]; the weight saving justifies the expense of the very efficient ventilation necessary to avoid exposing machinists to toxic quantities of beryllium dust.

REFERENCES

1. L. Gold. U.S.A.E.C. Report 1949, AECD-2643.
2. E. S. Ivanov and V. M. Shmelev. 2nd U.N. Conference on Peaceful Uses of Atomic Energy, 1958. Paper 2048.
3. W. W. Beaver. *Metal Progress*, 1954, **65**, p. 92.
4. J. Williams, W. Munro and J. W. S. Jones. A.E.R.E. Report 1955. M/R 1679.
5. T. R. Barrett, G. C. Ellis and R. A. Knight. 2nd U.N. Conference on Peaceful Uses of Atomic Energy, 1958. Paper 320.
6. H. H. Hausner and N. P. Pinto. *Trans. A.S.M.*, 1951, **43**, p. 1052.
7. N. P. Pinto. *Trans. A.I.M.E.*, 1954 **200**, p. 629.
8. J. Williams. *Metallurgical Reviews*, 1958, **3**, p. 1.
9. A. R. Kaufmann, P. Gordon and D. W. Lillie. *Trans. A.S.M.*, 1950, **42**, p. 785.
10. C. G. Hoffman and W. W. Beaver. U.S.A.E.C. Report 1949, BBC-47.
11. W. W. Beaver. *Metallurgy and Fuels* (Chap. 3), Pergamon Press, 1956.
12. S. M. Bishop. *The Metal Beryllium* (Chap. 5E), A.S.M., 1955.
13. K. G. Wikle. *Metal Industry*. Dec. 58. **93**, p. 529.
14. J. L. Klein, V. Macres, D. Woodward and J. Greenspan. *The Metal Beryllium* (Chap. 7D), A.S.M., 1955.
15. N. A. Hill. A.E.R.E. Memo. 1958, M/M 193.
16. J. Briola. 2nd U.N. Conf. of Peaceful Uses of Atomic Energy, 1958. Paper 1161.
17. J. T. Livey and J. Williams. *Ibid*. Paper 319.
18. D. C. Martin. *The Metal Beryllium* (Chap. 5G), A.S.M., 1955.
19. D. C. Martin *et al*. U.S.A.E.C. Report 1953, BM1-836.
20. D. R. Walker. *Mechanical Engineering*, 1958, **80**, p. 57.
21. *Metal Progress*, 1958, **74**, p. 105.

In the next issue the author discusses the problems associated with the handling of beryllium and its properties at room and elevated temperatures.

REPLICA METHOD OF FATIGUE INSPECTION

A PLASTIC replica technique has been developed by the Fulmer Research Institute, primarily for the routine inspection of components under fatigue stresses. The technique is simple and flexible and has been extended for use on various inaccessible components and failures. Inspection of the final replicas may be carried out with a simple optical microscope using reflected or transmitted light or with an electron microscope using secondary replicas.

Preparation of metal surfaces may be carried out by mechanical polishing, polishing in an electrolytic cell or, if carried out *in situ*, by the probe technique described by Jacquet. The replica material is in the form of strip and is applied to the surface together with a dilute solution of the strip in acetone; the solution is brushed on and requires a maximum of two minutes' drying time. Examination may be by reflected or transmitted light, and shadowing of the replicas improves contrast of fine detail such as slip lines. Secondary replicas can be taken from the original for more detailed examination by electron microscopy, for example, in the study of the early stages of crack formation.

This simple plastic replica technique gives faithful reproduction as shown in the photomicrograph of a weld [Fig. 1 (a)] and of a replica taken from the same area [Fig. 1 (b)]. It can be used to follow the fatigue life of part of a structure and gives a permanent record of change in surface topography, as illustrated in Fig. 1 (c). The technique is also useful for examining the surface of inaccessible components such as the failure shown in Fig. 1 (d), and, in summary, has proved invaluable as a means of non-destructive testing and inspection.

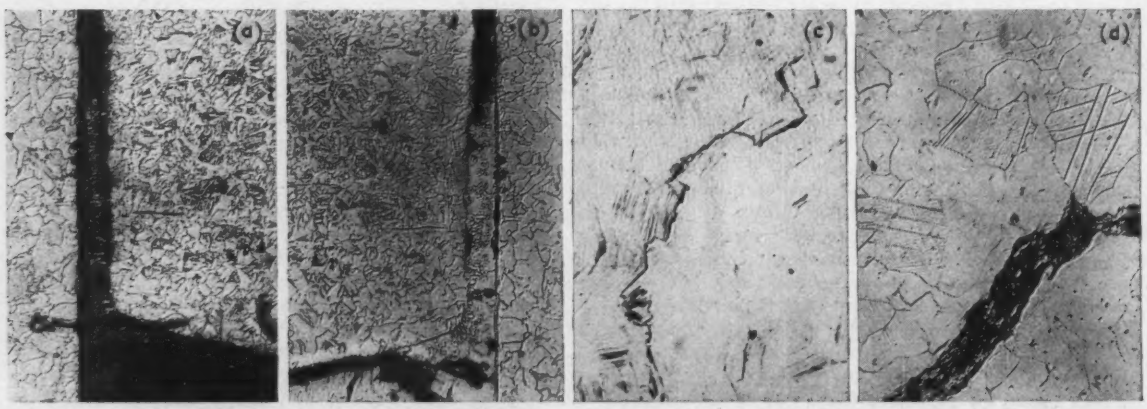


Fig. 1 (a) Photomicrograph of ferrous weld (×100). (b) Negative replica of same area as (a) (×100). (c) Replica of an α brass fatigue test specimen showing extensive cracking (×250). (d) Replica showing crack and Neumann bands in a large ferritic steel plate (×100).

SELECTION OF GASKET MATERIALS

There is hardly any field of industry in which gasket materials are not vital to everyday operation. This article shows how their selection is determined by particular service conditions and by specific environments

TO seal adequately two or more components, a gasket must be resistant to rough initial handling, temperature gradients, stresses during assembly and in use, and must be capable of taking uneven deformation without cracking or tearing. Far from being a mere accessory it may have to withstand more arduous conditions than the adjacent components, and should therefore be included as an integral part of the overall design problem. Yet when failure of a gasket occurs, it is often wrongly blamed because the characteristics and limitations of gasket materials are not sufficiently understood.

These materials are based principally on asbestos, vegetable fibre, other fabrics, cork, rubber, plastics, metals or jointing compounds. A combination of these may be necessary to obtain specific properties.

The following is a general guide to their selection, but the supplier should be consulted for detailed advice:

Asbestos-based Materials

The term asbestos is applied to a group of fibrous minerals which, after splitting, are capable of conversion to a yarn. The yarn may be reinforced with fine metallic wire or organic-type filaments and woven into fabrics; these, in turn, may be impregnated with rubber, plastics or other substances. The natural mineral fibre is resistant to corrosion, heat, acids and alkalis, and binds various fillers such as magnesia, cement and rubber. It may also be made into paper, millboard and felt.

The asbestos in most common use is white chrysotile. Crocilodite—or blue fibre—is less plentiful and more difficult to spin, but it has superior chemical resistance and is widely used in acid service; it has less strength than white asbestos and tends to cause scouring and wear in dynamic conditions.

Because the supply of long fibres for spinning is limited and because asbestos fibres are difficult to process, small quantities of other fibres, such as cotton, are normally added. This does not seriously impair the resistance of asbestos to heat and fluids, but it gives an increase in strength and a considerable reduction in cost.

Asbestos millboard contains up to 99 per cent asbestos fibre, with inert fillers. It is porous and the working temperature range extends from −185 to +550 deg. C. Being a weak material, pressures should not exceed about 100 p.s.i. and gaskets made from this usually have a minimum thickness of about $\frac{1}{8}$ in. Millboard is generally soft and may therefore be used effectively between rough sealing surfaces. The resistance to various fluids is the same as that of asbestos.

Many rubber-bonded gaskets are quoted by suppliers for service up to 480 deg. C., but it should be remembered that decomposition of the rubber may begin to take place at temperatures well below this figure.

Compressed asbestos is very heat-resistant; temperature limits are approximately −62 to +450 deg. C. and in certain cases from −185 to +550 deg. C. The pressure limitations are largely dependent on the mechanical features of the joint and may be as high as 2,500 p.s.i. In spite of the binder, compressed asbestos may be porous, and expert advice should be sought when the material is used for high-vacuum service or for gases under pressure where no leakage is permissible.

Compressed asbestos fibre gaskets are strongly resistant to plastic flow under heavy bolt load, but sufficiently compressible to compensate for slight irregularities in surfaces of flanged joints. They are only suitable for fitting between machined parts to effect a satisfactory seal.

Where high resistance to pressure and tearing is required, the asbestos may be reinforced by a gauze insert of brass or steel (the latter perhaps zinc coated). Alternatively, the asbestos may be faced with soft metal such as aluminium or copper as used for automobile cylinder-head gaskets.

If a particularly smooth surface or anti-stick properties are necessary for the impregnated asbestos sheets, graphite is added. Graphite has a low coefficient of friction and is either incorporated in a mix or applied externally after the packing has been fabricated. Solid graphite is also used as a packing material, but it is hard and brittle. Although the temperature and fluid resistance of graphite are very good, particles may be bonded with resin, thus affecting the characteristics. P.T.F.E. may also be used instead of graphite, where its extra cost is justified.

Vegetable-fibre Material

Vegetable-fibre gaskets with a plasticiser to reduce porosity and maintain softness are used in large quantities, even though the upper temperature limit is about 70 deg. C. and the maximum recommended pressure is about 500 p.s.i. Since vegetable fibres form the base, the service is limited to those fluids which will not attack these fibres, and as the material is usually hygroscopic, it tends to dry out and shrink.

Basic vegetable-fibre material bonded with rubbers (such as nitrile rubber) has higher temperature limitations, and certain grades may be worked at approximately 150 deg. C. Other compounds of vegetable fibre and cork are available, and where increased strength and resistance to tearing are required they may be reinforced with brass or steel wire inserts.

Papers

The cheapest gaskets are those made from organic paper, the service conditions for which are usually limited to a little over ambient temperatures, pressures below 100

Washing machine agitator being sealed with Thiokol LP.2 polysulphide rubber sealing compound.

p.s.i. and smooth sealing surfaces. Paper can be readily impregnated with a resin or elastomer to reduce the porosity, but it still has definite temperature limitations and will not resist many chemicals. Although paper gaskets are usually very thin and undergo very little compression and recovery, they may be supplied in almost any thickness and degree of resiliency, and are being made of other materials that will resist heat, flame, water and chemicals. Also being developed are papers of glass, silica and ceramic fibre that can endure heat from 550-1,250 deg. C.

Bagasse and bamboo papers are of interest primarily as substitutes for wood-fibre papers where wood is scarce, but fungus-fibre papers (made from the filaments of moulds and fungi) have special properties of their own, for they can be as strong as cellulose fibres, but have the advantage of being considerably more flame-resistant.

Cork-based Materials

Many gasket materials consist of cork particles which are soft and compressible, bonded together with glue, resin, protein or rubber, and in which the percentage of cork varies considerably. Glue or resin-bonded cork gaskets tend to be porous and are not satisfactory for gas service, the upper temperature limit for these materials being about 120 deg. C. Rubber-bonded cork is non-porous and has a temperature limit of 150 deg. C.

A combination of rubber, fibre and cork shows good strength, softness and compressibility, and this material will not crush under loads as high as 100,000 p.s.i. The maximum service temperature to be expected is about 150 deg. C., but the material tends to be porous.

Additional strength may be imparted to cork-based materials by the insertion of metal foils, fabric or paper, either as single thicknesses or as laminations. Alternatively, the cork base may be faced with processed paper or other forms of vegetable fibre.

The rubbers used for impregnations or bonding vary according to the purpose for which the gasket is intended, but the more popular are the neoprene and nitrile types.

Generally, the bonded corks are resistant to oils, fuels and coolants, also to weak acids and alkalis, but should not be used with high-pressure steam.

Natural and Synthetic Rubbers

The extensive use of rubber as a sealing material for gaskets, jointings and packings is due to its unique elastic properties. But the rubber must also be chosen for its properties of heat and oil ageing, compression set, load/deflection, low and high temperature, tear resistance, flexing, abrasion, adhesion, flame resistance, moisture absorption, anti-freeze liquid resistance, impact resilience, staining, ozone resistance, tensile strength, load extension and degree of hardness.

For use as gaskets, rubber-base materials may be used either in a single thickness, laminations of different types or in combination with vegetable fibres, cork or asbestos. They may also be reinforced by fabric or metal gauze inserts. In some circumstances it may be desirable to use a grade of foam or sponge rubber.

Deflection of rubbers in compression or tension occurs at relatively low loading pressures; such deflection is substantially reversible. At higher loading pressures and consequently larger deflections, plastic flow or creep may become serious, this being particularly the case at elevated temperatures. The effect of compression set or compression stress decay is to relax progressively the sealing pressure exerted by the gasket, although, in a well-vulcanised rubber at ambient temperatures, the rate of relaxation will become quite slow after the first few minutes' service. However, for certain synthetic rubbers at elevated temperatures and for thermoplastics, care in formulation and processing will be required to overcome deficiencies in this respect.

Since rubber has a high elongation and relatively low strength, gaskets made of it should be confined if they are to be used at pressures above a few p.s.i. Rubber is not truly compressible, so, when it is confined, sufficient space should be allowed for distortion, but the load necessary to effect a seal is relatively small because the material is soft enough to flow readily into the irregularities of a rough surface.

It is not generally recommended that natural rubber gaskets should be compressed to less than 70 per cent of their original thickness.

The rubber compound must act as a seal while subjected to many varying chemical and physical conditions. No single natural or synthetic rubber has all the properties demanded by industry, and to meet the many specifications, use must be made of combinations of the range.

Natural rubber is tough, resilient, and can be compounded to provide Shore hardnesses of 35-80. It is commonly used against cold and hot water, various water solutions (not concentrated acids), vegetable oils and gases. It has excellent flexibility and resilience over a temperature range of −50 to +110 deg. C.

Butadiene-styrene rubbers (S.B.R.) show generally higher compression set and lower resilience than natural rubber. They are not petrol-resistant, but may swell less in certain blends, though this swelling may be accompanied by a greater loss of strength than is the case with natural rubber. At high temperatures, S.B.R. hardens while natural rubber softens; since both phenomena involve loss of elastic properties, the choice may depend on individual applications.

Neoprene rubber is used where medium oil resistance, combined with flame retarding, ozone resisting and good ageing properties are required. It has high tensile strength and excellent abrasion resistance; its resistance to aromatics is limited.

Butyl rubbers are resistant to light ageing, oxygen, ozone and general weathering. They are also resistant to many

chemicals, including acids and alkalis. They are inherently resistant to oxidation degradation at high temperatures, but tend to soften by "reversion" unless specially compounded. Compression set is higher than is the case with natural rubber, S.B.R., neoprene or nitrile rubbers, and resilience is low at ambient temperatures, but increases rapidly to a high value at about 70 deg. C. or above. Like natural rubber, butyl is resistant to water and ethylene glycol coolants and is generally superior to nitrile and neoprene rubbers in this respect. Although resistant to vegetable oils, it is not so to mineral or aromatic oils or solvents. It has extremely low permeability to gases.

Nitrile rubbers (N.B.R.) are resistant to abrasion, heat, petrol, mineral and vegetable oils, paraffin and anti-freeze mixtures and have a high tensile strength. They are largely used as seals for diesel fuel and detergent oils and may be compounded to function well between −30 and +120 deg. C.

Nitrile rubber-p.v.c. blends give materials of two main types in each of which the oil resistance of nitrile rubber is combined with the chemical resistance of p.v.c. Blends in which the nitrile rubber predominates are harder than the straight nitrile rubber and are more resistant to the effects of solvents, high temperatures and oxidation. In predominantly p.v.c. blends the nitrile rubber acts as a non-volatile, non-extractable plasticiser, imparting high impact strength initially, a characteristic which is, however, reduced with ageing.

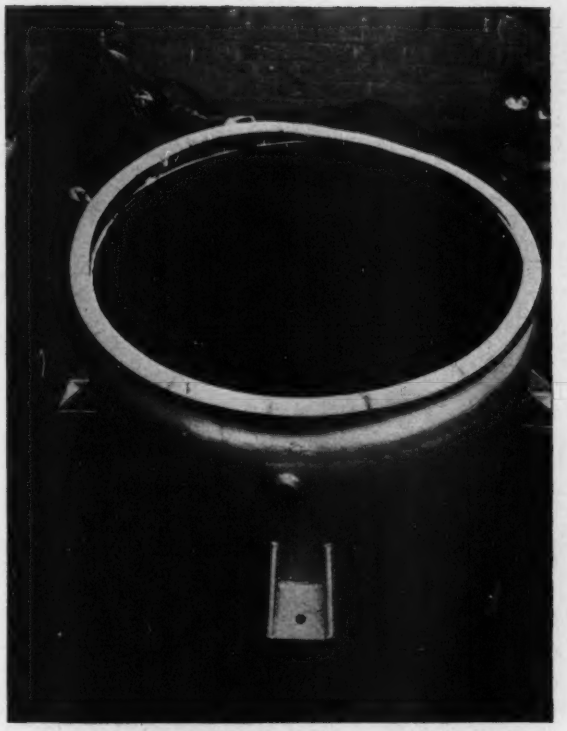
Silicone rubbers find almost exclusive use where very high- and low- temperature conditions must be met. They have a normal working temperature range of approximately −50 to +200 deg. C. but grades are available which remain serviceable beyond these limits. In general, they are resistant to most alkalis, weak acids, ozone and some oils, but as a rule are unsuitable for use with petrols, fuels and aromatic solvents because of excessive swelling. For use with steam under pressure, careful choice of the grade is necessary, but as they are highly water-repellent, all grades will give good service in hot, moist conditions.

Fluoro-silicone and nitrile-silicone rubbers combine the many desirable features of silicone rubbers with resistance to fuels and oils. Their low-temperature properties are excellent and their resistance to high temperature, although good, is slightly lower than those of normal silicone rubbers.

Fluoro-carbon rubbers are costly and often difficult to process but show great promise because of their resistance to oxidising chemicals such as nitric acid, hydrogen peroxide and liquid oxygen. Their heat resistance is much better than nitrile rubbers, but as a rule is not quite equal to that of silicone types. They are suitable for use exposed to many oils and hydraulic fluids.

Polysulphide-organic dihalide polymers have the highest resistance to solvents of all synthetic rubbers and are used where maximum oil resistance is required. They remain flexible at −50 deg. C. and can be used, for intermittent service, at 120 deg. C. Their greatest disadvantage is their tendency to cold flow, as a consequence of which they cannot be used under conditions of tension or compression unless special precautions are taken. The low shrinkage of the liquid forms often allows them to be used for "cast-in-place" applications, as vulcanisation may be achieved without application of heat and pressure. The solvent resistance of polysulphide rubbers is better than that of nitrile rubber. Compression set is very high and the general level of physical properties lower than for most other rubbers; hence, the use of blends of nitrile and polysulphide rubbers to meet stringent specifications.

Polyacrylic rubber is used where good resistance to temperatures up to 160 deg. C. and to oils at high temperature is required. Chlorosulphonated polyethylene may be used similarly, being flame-retardant but less oil-resistant.



Fluolion envelope gaskets made by James Walker & Co. from Fluon p.t.f.e. are used by Enamelled Metal Products Corp. to seal glass-lined tanks for processing corrosive liquids.

Nitrile-p.v.c. blended polymers provide the oil resistance of the nitrile rubber combined with the ozone resistance of the p.v.c., but compression set is apt to be a problem particularly above ambient temperatures.

Plastics

Polyvinyl chloride is a tough thermoplastics sheet with high impact strength. Dimensional stability in atmospheres of varying humidity and resistance to weathering are good, and the material is non-inflammable in the sense of being entirely self-extinguishing. It should not be used in temperatures above 60 deg. C. It is very resistant to strong acids, alkalis, aqueous solutions and moist gases, although some absorption of water occurs at high temperatures.

Polythene is one of the lightest plastics known and has excellent stability under all normal conditions, including total imersion in water and exposure to high humidity. It is also noted for its extreme toughness and flexibility, withstanding temperatures up to about 100 deg. C. and remaining non-brittle down to −40 deg. C. Being chemically inert, polythene is virtually unattacked by most chemicals at room temperatures and is very resistant to water and water vapour. It is completely resistant to solutions of inorganic salts up to 100 deg. C. and is insoluble in organic solvents, although some softening, embrittlement or crazing may occur; it is only affected by those acids which have an oxidising effect at high concentrations. Polythene is highly resistant to alkalis, although oils cause swelling. It will not support mould growth, but is permeable to all gases.

Polytetrafluoroethylene has excellent temperature characteristics, chemical inertness and solvent resistance. Due to its rather poor creep resistance, care should be exercised in the design of the mating ports. The service temperature range is −100 to +250 deg. C. which may in special circumstances be extended. It has remarkable non-sticking properties, is non-wetting and has such a low coefficient of

Temperature ranges suitable for various gasket materials. Values shown are average for the particular class of material; specific products may have enhanced properties. Low-temperature values are quoted where figures are available.

friction that it is virtually self-lubricating. In the massive form the material has a smooth, waxy feel, and in thin sections is translucent or transparent. It is non-inflammable and has a high impact strength, especially at elevated temperatures. In thin sheets, p.t.f.e. is extremely pliable, is light, stable, has a nil water absorption, is attacked only by molten alkali metals and fluorine and has no known solvents.

Acrylic materials are thermoplastic and little affected by outdoor exposure. They have low water absorption characteristics, and although the thermal expansion is high they are otherwise dimensionally stable and are tough rather than brittle. At room temperatures the material is rigid, but as the temperature is raised a gradual change takes place and it becomes soft. This change of state, which is reversible, does not occur at one particular room temperature, but occurs gradually over a range from approximately 80-100 deg. C. Broadly, the material is resistant to inorganic chemicals and many organic compounds, but is attacked and weakened by esters, ketones, etc. The surface hardness or resistance to scratching is comparable with that of aluminium, and the burning characteristics may be classified as slow burning and not readily ignited.

Nylon polymers are characterised by their great strength, toughness and resistance to abrasion, their excellent resistance to most organic solvents and their high but sharp melting points. Their resistance to alkaline solutions and dilute caustic alkalis is good, their resistance to acids moderate.

Nylon materials can be made available with properties varying over a wide range. The temperatures at which nylons melt depend on the type of composition, but they are considerably higher than the softening temperature of most thermoplastics, and may be worked continuously at 150 deg. C. At elevated temperatures they are subject to oxidation with embrittlement, the mechanical properties being less dependent on temperature than are those of most thermoplastics. Nylons are hygroscopic, and since water has a plasticising effect, their properties vary slightly with moisture content. Immediately after moulding, nylon may be brittle, but by "conditioning", either by boiling in water or allowing the mouldings to stand exposed to the air for some time, an equilibrium point is reached at which optimum values for impact and tensile strengths are obtained.

Cellulose nitrate materials are almost invariably plasticised with camphor, and are unaffected by dilute mineral and acetic acids. Concentrated acids, particularly the oxidising types, will cause a complete breakdown, although the resistance of cellulose nitrate material is rather better than cellulose acetate. Cellulose nitrate may be swollen or dissolved by many organic solvents, particularly ketones, esters, lower alcohols and glycol ethers. It has good resistance to water and aqueous solutions of organic salts, is not dissolved by commercial petrols, and offers good resistance to the action of oils and fats.

Cellulose acetate is characterised by excellent transparency and stability and has a softening point of 95 deg. C. All dilute mineral acids attack this material, but the effect is only severe with concentrated solutions or at high temperatures. It may be swollen and softened by dilute and concentrated alkaline solutions, but it has good resistance to aromatic hydrocarbons. Although unaffected by all vegetable and mineral oils, it should not be used in contact with edible oils.

The chemical resistance of polystyrene is good, as it is not affected by dilute mineral acids or aqueous solutions of the common alkalis. It is swelled but not dissolved by paraffinic hydrocarbons, being soluble in aromatic and chlorinated hydrocarbons. Polystyrene is not normally affected by vegetable oils and fats, although light mineral oils such as kerosene will cause crazing of stressed polystyrene. Special grades have been developed which avoid this disadvantage.

Casein formaldehyde is less pliable than cellulose or vinyl plastics, and is non-inflamable and odourless. It is hygroscopic and should be used in an atmosphere of constant humidity.

P.C.T.F.E. (polymonochlorotrifluoroethylene) has many of the characteristics of p.t.f.e. but it is more easily worked. Thus, an injection moulding technique is feasible instead of the powder metallurgy technique which has to be used for p.t.f.e. In general, the properties of p.c.t.f.e. are slightly inferior to those of p.t.f.e., but it has excellent low-temperature flexibility, thin sections maintaining their flexibility at −200 deg. C.

Polyurethanes vary widely in chemical constitution, but as a class are similar to the nylons except that they have, in general, lower water absorption and considerably lower melting points. They are resistant to ageing by ultra-violet light and oxidation (including attack by ozone) and they do not readily burn. Although oil- and solvent-resistant, they are susceptible to hydrolysis under acid, alkaline or hot, damp conditions.

Chemically modified polyurethanes have very low gas and petrol vapour permeabilities and are oil resistant.

Many of the foregoing materials may be reinforced with either fabric or wire insertions to give greater strength. They may also be used in the form of coatings, on other materials to give a combination of properties.

Although not widely used for gaskets, foam materials may have certain applications where a high degree of resilience is required.

Leather

Leather is not normally a material which is suitable for gaskets, as it tends to absorb the fluids being handled, some

TABLE I. General suitability of gasket materials in various environments

	Butyl	Natural Rubber	P.T.F.E.	Neoprene	Asbestos	Nitrile Rubber	Cork	Vegetable Fibre	Unplasticised P.V.C.	Plasticised P.V.C.	Nylon	Silicones
Acids	F	F	G	F	G*	F	B	B	G	G	B	F
Alkalis	G	F–G	G	F	G	F	B	B	G	G	F	G
Air	G	F	G	G	G	F	G	G	G	G	G	G
Ammonia gas	F	G	G	F	G	F	B	B	G	G	F	G
Oxygen	F	B	G	F	G	F	F	F	G	G	G	G
Oils (animal and vegetable)	G	G	G	F	G	G	G	G	G	F	F	G
Oils (mineral)	B	B	G	F	G	G	G	F	G	F	F	G
Petrols and paraffins	B	B	G	G	G	G	G	G	G	F	G	G
Chlorinated hydrocarbons	B	B	G	B	G	B	G	G	B	B	G	B
Ketones and esters	G	F	G	F	G	B	G	F	B	B	G	F
Steam	F	F	G	F	G	F	B	B	B	B	F	G
Water	G	G	G	G	G	G	F	F	G	G	G	G
Seawater and brine	G	G	G	G	G	G	F	F	G	G	G	G

G—Good. F—Fair. B—Bad. * blue asbestos

of which will cause it to swell excessively. High temperatures will dry the material so that it becomes hard and brittle and subject to cracking.

Metal Gaskets

Metal gaskets are used mainly for resistance to high- and low-temperature applications.

Lead has a low creep resistance and care must be taken that it is not squeezed out of the joint. Aluminium is suitable for hot and cold oils, solvents, petroleum distillates and coal tar fuels, particularly those with high sulphur content, but is attacked by strong acids and alkalis; working temperature range is up to 430 deg. C. Copper and brass are resistant to most solvents and petrols but are unsuitable for coal tar fuels, oxidising acids, wet ammonia, chlorine and sulphur; hydrogen, carbon monoxide and reducing gases at high temperature cause embrittlement. Temperature range is up 540 deg. C.

Soft iron is used mainly in the petroleum industries for handling hydrocarbon services at high temperatures and pressures. Low-carbon 18/8 chrome-nickel stainless steel has excellent chemical resistance and can be used in most temperature and corrosive conditions.

Most metals have sufficient strength to withstand ordinary pressures, but special joints may have to be designed for very high pressures. They have a minimum of resilience and are not recommended for cyclic service.

If a washer-type gasket is punched and corrugated in a concentric manner, a gasket is obtained which has a greatly reduced area of sealing. Only the tops of the corrugations come into contact with the sealing surfaces, and this causes a concentration of the sealing load on a limited area instead of over the entire gasket surface. In this way the total load necessary for sealing is greatly reduced. The corrugations can be used to retain another sealing material such as asbestos, p.t.f.e. or a compound, which then effects the actual seal, the metal serving as a retainer and a secondary seal. Since a corrugated metal tends to relax at elevated temperatures, this type is generally limited to temperatures below 100 deg. C. Corrosion and temperature resistance are imparted by the metal facing and the filler contributes compressibility and resilience normally lacking in solid metal gaskets.

The spirally wound gasket exhibits a greater resilience and consists of alternate layers of a thin strip of beaded metal and a filler such as asbestos paper. The edges of the strips form the sealing surfaces. When a load is applied to the gasket, it undergoes compression by deformation at the bead and bending of the strips, and when the load is removed the gasket tends to return to its original shape. These gaskets are excellent for high-temperature cyclic operation and can be used at almost any pressure, although their shape is in general limited to symmetrical patterns.

Also of interest are "envelope" gaskets, i.e., a p.t.f.e. surrounding an insert of proofed or compressed asbestos or synthetic rubber to provide flexibility and compressibility. These can be used to handle the most stringent chemical services at temperatures up to 260 deg. C., but relatively high flange loading is needed to obtain satisfactory sealing.

Felt

Felt is not normally regarded as a gasket material, but it may be used in certain instances where excellent resilience is required at a joint. It is unaffected by temperatures up to 100 deg. C. After contact with water it will dry out and recover its original properties. Felts may also be impregnated with various compounds to meet specific applications and environments.

Fabrics

In the main, fabric materials used for gaskets consist of asbestos, cotton, linen or muslin impregnated or vulcanised with suitable fillers. Cotton has high tensile strength which increases approximately 20 per cent when the fibre is wet. At temperatures above 150 deg. C. cotton will carbonise and lose strength rapidly; 90 deg. C. is considered to be its continuous working temperature limit. Cotton is unaffected by cold weak acids, but is disintegrated by hot dilute acids or cold concentrated acids. It swells in caustic but is not damaged and is completely resistant to organic solvents. Glass cloth is also used as a base and may be coated with, for example, a silicone rubber. To achieve greater strength, the fabric may be spun initially with a wire fibre or may be laminated with a wire gauze insert.

Proofed cloth gaskets are most commonly used in such varied applications as boiler manholes and handholes, also on steam-heated oven doors, steam-chest covers, calorifiers, autoclaves and boiling pans. They will seal effectively on rough and slightly distorted flanges and, dependent on the proofing material, may be used in most services. Temperature limits depend mostly on the proofing materials, but even after this has disintegrated the body of the joint remains intact.

Jointing Compounds

In many applications, particularly where there are irregular surfaces and low pressures, it may be expedient to use liquid or semi-liquid compounds consisting of various bases and fillers. Operating conditions should determine whether the compound must set hard or remain flexible.

We wish to acknowledge with thanks the assistance given in the preparation of this article by D. A. Smith of the National College of Rubber Technology, by Bell's Asbestos & Engineering Ltd. and I.C.I. Plastics Division.

MAIN AVAILABLE RANGES OF GASKETS

CORK-BASE MATERIALS

Range	Composition and Approp. Spec.	Suitable Environment
Armstrong Cork Co. Ltd.		
Uniphase	Synthetic elastomeric binder.	100°C., 30 p.s.i. Flange pressures 4,000 p.s.i.
Beldam Asbestos Co. Ltd.		
Lascaroilite	—	Oil, petrol, fuels. 120°C. Not for wet steam or mineral acids.
Lascarkork Reinforced	With fabric or aluminium foil reinf.	Oils, petroleum distillates. 65°C.
Lascarkork	—	Oils, petrols at low temperatures and pressures.
Bell's Asbestos & Engineering Ltd.		
J.102	Neoprene bonded cork (D.T.D. 762).	
J.103	Laminated cork paper reinf.	Oil, petrol, water. 120°C.
J.104	Paper-faced cork.	
British Technical Cork Products Ltd.		
Four grades	Cork and nitrile rubber.	Oils, aqueous coolants, anti-freeze solutions. 150°C.
Chillcotts Ltd.		
Paroid DC series (various grades)	Cork and synthetic rubber.	Oil, water, kerosene, glycol. 40–120°C.
Paroid RC 43	Cork and natural rubber.	Hot, cold and salt or fresh water.
Plain cork	Resin bonded (D.T.D. 789).	—
Cork	Laminated with fabric or X-fibre.	—
Fibracork	Cork sheet faced with X-fibre.	Oil, petrol, water.
Coopers Mechanical Joints		
Agglomerated corks	Protein bond. Synthetic phenolic bond.	120°C. 150°C.
Reinforced cork	Aluminium or steel reinf.	120°C.
Reinforced cork	Muslin, manilla or processed paper reinf.	—
Corok	Cork sheet faced with processed paper.	—
Corrub	Nitrile rubber-bonded.	Ester-based oils, petroleum fuels, coolants, detergents, mineral oils.
Cork Manufacturing Co. Ltd.		
Langite	Various grades (DEF. 19A and 219).	Oil, petrol, various chemicals.
Oakencork	Impregnated vegetable fibres and cork.	140°C.
Hall & Hall Ltd.		
Hallprene Cork	—	Oil, refrigerants. 150°C.
Corkinsert	(D.T.D. 762) Linen reinf.	—
Harold Jackson Ltd.		
Oakencork	—	Oil, petrol. 140°C.
Kautex Ltd.		
Neo-K-Tex	Synthetic rubber-bonded.	40–120°C. Oil, petrol, industrial solvents and gases.
Grade NC. 2 A	As above, with asbestos powder.	—
Stephens Gaskets Ltd		
Stencork (cork sheeting)	With/without linen inserts.	
Stencorro XK	With synthetic rubber.	
H. J. Stevens & Sons		
Various qualities to order		
Ronald Trist & Co. Ltd.		
Seatrist laminated cork		Oil, petrol.
Vulcascot (Gt. Britain) Ltd.		
Bonded cork		Oil, water, solvents, fuels, acids, alkalis. −20 to +150°C.
James Walker & Co. Ltd.		
Lioncelle grade CN	Cellular sponge cork, natural rubber-bonded.	Water, air.
Lioncelle grade CS	Synthetic rubber-bonded.	Oil, solvents, fats.
Nebar	Synthetic rubber-bonded (D.T.D. 762).	Oils, glycol, fuels. −30 to +150°C.
Coruso	Natural rubber-bonded.	Water and air.
Transoyl	Fine-grain cork with vegetable fibre inlay.	Oil. To 95°C.
Whitby & Chandler Ltd.		
Various qualities to order		
Wood Bros. & Co. (Gaskets) Ltd.		
Various qualities to order		

ASBESTOS-BASED MATERIALS

Range	Composition and Approp. Spec.	Suitable Environment
Geo. Angus & Co. Ltd.		
Angusite	Plain, graphited or with wire gauze insert.	General purpose for medium pressure, steam, oil, gas, weak chemicals.
Atholl Asbestos & Rubber Co. Ltd.		
	Various grades to order.	
Beldam Asbestos Co. Ltd.		
Asoid	(D.T.D. 378.)	Oil, steam, chemicals. 1,500 p.s.i., 600°C.
Lascarite	—	Steam, water, chemicals. 1,200 p.s.i., 570°C.
Lascarite reinforced	Rustproof steel wire reinf. (D.T.D. 416.)	2,000 p.s.i., 650°C.
Kymbala	—	H.P. steam, chemicals. 1,500 p.s.i., 650°C.
Blackamoor	Graphite finish.	Water, steam. 1,500 p.s.i., 600°C.
Bufsarite	—	Oil, steam, gas. 850 p.s.i., 540°C.
Sarite	—	Steam. 630 p.s.i., 450°C.
Asbestos millboard	—	—
Metallic	Brass wire reinf. Graphite finish optional.	Steam, water, gas, chemicals. 300 p.s.i., 315°C.
Cormac	Soft white metal wire woven with asbestos. Graphite finish optional.	Steam, water, gases, certain chemicals. 150 p.s.i., 175°C.
Lascid	Woven asbestos cloth.	Acids. 150 p.s.i., 150°C.
Lascaroil	Graphite coating optional.	Oil, petrol. 250 p.s.i., 350°C.
Baco	Laminated dry asbestos sheet.	480°C.
Lascar	Impregnated cloth. Graphite finish optional.	250 p.s.i., 260°C.
Lascarflon	Impregnated with p.t.f.e.	Corrosive liquids, strong acids. 200 p.s.i., 300°C.
Chillcotts Ltd.		
Reinz-Repa	Woven wire reinf. asbestos filled.	4,400 p.s.i., 600°C.
Reinz super special	Zinc-coated steel reinf., asbestos filled.	30,000 p.s.i., 600°C.
Bell's Asbestos & Engineering Ltd.		
J.80	Plain finish. (B.S. 2815, grade A.)	Superheated steam to 1,000 p.s.i., 537°C. Gases, liquids, petrol.
J.52 Salamanderite	(B.S. 2815, grade B)	Superheated steam, chemicals, weak acids. 550 p.s.i., 454°C.
Bellite	(B.S. 2815, grade B.) Plain or graphite finish or steel gauze reinf.	Saturated and superheated steam. 450 p.s.i., 427°C.
J.71	Aircraft non-metallic (D.T.D. 378). With steel gauze reinf. (D.T.D. 416).	800 p.s.i., 510°C.
J.72	(D.AT.EN.70142.)	Nitric, sulphuric, hydrochloric acids. 204°C.
J.454	Graphite finish with steel gauze reinf.	Exhaust gases. 649°C.
J.21	(B.S. 2815, grade A, and 1832.) Wire reinf. optional.	Oil, steam. 800 p.s.i., 482°C.
J.20	Special duty H.P. jointing, synthetic rubber-bonded. (B.S. 1832 and 2815.)	800 p.s.i., 482°C.
J.22 Bellprene	Neoprene-bonded (D.T.D. 378).	Jet engine fuels, oxygen, superheated steam, oils, refrigerants. 800 p.s.i., 482°C.
Asbestos millboards		
Cape Asbestos Co. Ltd.		
Super Capyt SC 151		General purpose. Superheated steam temperature. Not recommended for hot aromatic oils and strong acids.
Capyt C.101	Metal reinf. optional (D.T.D. 416 and 378A).	H.P. steam, alkalis, neutral chemicals. Not for strong acids.
Plutite P 51	—	General purpose for medium and H.P. steam.
Rhodite R 10	—	Commercial grade for steam jointing.
Rhodite R 21 X (export)		
Capyt-oil CO 201	Synthetic rubber base.	Steam, oils, petroleum, solvents.
Capyt-acid CA 301	(D.AT.EN.70142.)	Acids.

ASBESTOS-BASE MATERIALS (CONTD.)

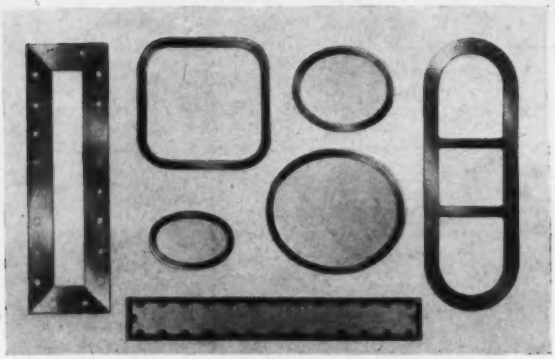
Range	Composition and Approp. Spec.	Suitable Environment
Coopers Mechanical Joints Ltd.		
Cooperite		Petrol, oil.
Permanite Aero	Steel gauze reinf. Plain or graphite surfaces (D.T.D. 416).	General purpose for low pressure steam, water gas, petrol, oil. 700 p.s.i., 510°C.
Permanite Aero plain	Synthetic rubber bond (D.T.D. 378).	Oils. 800 p.s.i., 510°C.
CAF 229	(B.S. 1832).	Hot oils, petrol, benzol and most organic solvents.
CAF 400	Nitrile rubber bonded.	Hot oils, refrigerants, fuels. 750 p.s.i., 480°C.
MBR Jointing	Asbestos metallic cloth coated with heat-resistant compound.	For rough faces with steam, hot and cold water.
CEMJO steel-asbestos	Double and single steel faced.	Cylinder heads, manifold gaskets.
Asbestos millboards and papers	—	Water-resistant.
Asbestos cloths	Non-metallic or wire woven.	—
Coopers No. 14	Asbestos cement core faced with asbestos fibre.	300°C. Spacers on carburetters, etc.
CSIM	Moulded asbestos composition (phenolic resin, slate powder).	—
G.63	Asbestos fibres bonded with synthetic rubber.	Heat, fuels, oils. Sump joints, etc.
Crane Packing Ltd.		
Cranpac style 33	Impregnated asbestos.	Superheated and saturated steam, air, gas, brine, alkali.
Cranpac style 88	Asbestos with oil-proof and heat-resistant binder.	Oils, refinery gases, refrigerants, many chemicals.
Cranpac style 215	Impregnated asbestos.	Caustic alkalis, conc. nitric acids.
Cork Manufacturing Co. Ltd.		
Chingford Grades B and C	General purpose.	Steam, water , gas. 250 p.s.i., 450°C.
Chingford Grade D	May be graphited.	500 p.s.i., 480°C.
Chingford Aero	(D.T.D. 378.)	—
Chingford metallic	—	Exhaust joints, etc. 1,000 p.s.i., 540°C.
Chingford Aero-metallic	(D.T.D. 416.)	—
Chingford oil	—	Oils. 350 p.s.i., 450°C.
Asbestos millboard	—	—
Hall and Hall Ltd.		
Proofed asbestos	Soap-stone or graphite finish.	Heat resistant.
Blue asbestos	—	Acids, chemical solutions.
Hallite	Graphited (B.S. 1737 and 1832; grade G).	Steam, oil, water. 350 p.s.i., 425°C.
Hallite metallic	Brass gauze reinf., graphite finish.	Exhaust manifolds and diesel applications.
Hallite super metallic	Steel gauze reinf. (D.T.D. 416).	650 p.s.i., 480°C.
Hallite Aero jointing	Red or graphited (D.T.D. 378A).	Hot oil. 800 p.s.i., 510°C.
Hallite H.P. jointing	Non-graphited (B.S. 1832; grade G, and 1737).	—
Leadenhall blue jointing	Plain or graphite finish.	250 p.s.i., 315°C.
Iceberg	(B.S. 1832; grade H.)	Refrigerants, petrol, solvents 650 p.s.i.
Oldfield	Red or graphited.	Medium temperature applications.
Richard Klinger Ltd.		
Klingerit	Graphite finish optional (D.T.D. 378A, B.S. 2815 and 1832).	Steam, oils, solvents, chemicals.
Klinger 721	Graphite finish optional (D.T.D. 378A).	Oils. Gas turbine synthetic lubricants and fuels.
Klinger 1000	Steel gauze (D.T.D. 416) or bronze reinf.	Extremely high temperatures.
RK jointing	—	Steam, air, chemicals.
Klinger-Oilit	—	Maximum oil resistance.
Klinger-Acidit	—	Acids.
Small & Parkes Ltd.		
Fepco (Std.)	Red or graphited asbestos fibre.	Water, gas, weak chemicals, etc., to 200–300 p.s.i., 425°C.
Fepco (TFW)	High-grade red or graphited.	High-pressure steam, water, oils, petrol and solvents to 650–800 p.s.i., 500°C
Fepco (TNT)	(D.AT.EN.701).	Acids to 200°C.
Asbestos millboards	—	—
Railite L.P. jointing	Red or graphited rubber-bonded asbestos.	Steam, water, gas and weak chemicals to 200 p.s.i., 425°C.
Railite asbestos	Rubber-proofed asbestos cloth.	220 p.s.i. (higher for Admiralty quality).
Stephens Gaskets Ltd.		
Stenseal 1A	Compressed asbestos fibre jointing.	Oils, petrol and steam. 1,320 p.s.i., 200–260°C.
Stenseal 2A		250 p.s.i., 310–380°C.
Stenseal 3A		L.P. steam, water and gas. 200 p.s.i., 200–240°C.
H. J. Stevens & Sons		
	Compressed asbestos fibre to order.	
Ronald Trist & Co. Ltd.		
Seatrist general	—	General engineering applications.
Seatrist standard	—	Superior quality.
Seatrist special	Graphite finish.	Superheated steam to 315°C.
Seatrist superheat	—	Steam to about 400°C.
Seatrist oil	—	Oils.
Seatrist reinforced	Graphite finish. Steel gauze reinf.	
Turner Brothers Asbestos Ltd.		
Permanite	Red or graphite finish (B.S. 2815, grade A).	Steam, oil, petrol. 950 p.s.i., 510°C.
Permanite Aero	Red or graphite finish (D.T.D. 378A).	Fuels, oil, gases. 850 p.s.i., 510°C.
Permanite Aero metallic	Red or graphite finish (D.T.D. 416).	Fuels, oil, gases. 750 p.s.i., 510°C.
Permanite oil jointing	Black or graphite (B.S. 1832).	Oil and petroleum distillates, refrigerants. 800 p.s.i , 510°C.
Permanite acid jointing	(D.AT.EN.70142 B.)	Nitric and H_2SO_4. 205°C.
Permanite metallic	Graphite finish only. Steel gauze reinf.	H.P. steam, I.C. engines. 700 p.s.i., 480°C.
Permanite Style 400	Plain or graphite finish. Synthetic rubber bonded.	Hot fuels, oils, solvents. 700 p.s.i., 48°C.
Permanite Style 500	Synthetic rubber bonded.	Oils, refrigerants. 750 p.s.i., 480°C.
CAF 4	Red or graphite finish.	H.P. steam. 650 p.s.i., 454°C.
CAF 9	Vulcanised; red or graphite finish.	Wet steam, gases, chemicals. 400 p.s.i., 425°C.
CAF 40	Red or graphite finish.	275 p.s.i., 380°C.
Vulcascot (Great Britain) Ltd.		
Compressed asbestos fibre.	Various qualities to order.	—
James Walker & Co. Ltd.		
Lion	Asbestos fabric interwoven with white metal and brass wire.	Steam. 230°C.
Maybury	Cheaper quality than Lion.	Low- and medium- pressure steam.
Furic	Impregnated blue asbestos fabric.	Acids. 65°C.
Lionite	Impregnated white asbestos.	Nitric acid. 66°C.
Twilstele	Steel wire reinf. asbestos fibre yarn.	Oils, dry heat. 600°C.
Super Twilstele	Stainless steel wire reinf.	Wet heat. Above 600°C.
Super Golden Walkerite	Graphite, plain or gilded finish.	Organic acids, dilute mineral acids, wet steam. 540°C.
Walkerite	Steel or brass reinf., graphite finish.	Dry heat. 540°C.
Dandylion	Plain or graphite finish, with/without brass wire reinf.	Steam, organic and dilute mineral acids. 370°C.
Greydaye	Plain or graphite finish (B.S. 2815, grade B). Brass reinf. optional.	Steam, water, 260°C.
Lipackite	Plain or graphite (B.S. 1737). Brass wire reinf. optional.	Steam, water. 200 p.s.i., 200°C.
Unilion	Steel gauze reinf. optional (B.S. 1832).	Water, oil, alkalis, acids, hydrocarbons. 750 p.s.i., 300°C. (460°C. for reinf. mat.)
Grafitoil	Synthetic rubber-bonded (D.T.D. 378A). Steel gauze reinf. optional.	Oils, solvents, 1,000 p.s.i. 315°C.
Nitrylite	Nitrile-bonded.	Oil, fuel.
Sulfesto and Nitresto		Sulphuric or nitric. 500 p.s.i., 200°C.
Whitby & Chandler Ltd.		
Witchan	P.T.F.E.	General purpose. L.P. steam, water, gas, weak chemicals. 200 p.s.i., 425°C.
Witchan super		400 p.s.i., 425°C.
Witchan 500		650 p.s.i., 450°C.
Witchan 1000		700 p.s.i., 510°C.
Witchan 2000	Steel gauze reinf.	Oils, petrols, H.P. steam, alkalis. 2,000 p.s.i., 540°C.
Chanoid	—	Oils, solvents, petrol. 800 p.s.i., 510°C.
Super Chanoid	—	Oils, fuels, refrigerants. 750 p.s.i., 480°C.
Witchan Acid.	—	Nitric, sulphuric. 200°C.
Witchan Flywell	(D.T.D. 378.)	850 p.s.i., 510°C.
Witchan Precision	Wire gauze reinforced. (D.T.D. 416).	750 p.s.i., 510°C.
Asbestos millboard	—	—
Asbestos millboard	—	—
Asbestos cloths	Plain or proofed with natural/synthetic rubber. Graphited.	—
W. H. Willcox & Co Ltd.		
Jointite	Red or graphited.	H.P. steam, oils, petrol, acids, alkalis.
Wood Bros. & Co. (Gaskets) Ltd.		
Standard Masterite	General purpose.	Steam, water, oils, acids, alkalis.
No. 1 Masterite	—	350 p.s.i., 430°C.
Super Masterite	—	2,000 p.s.i., 500°C.
Acid-resistant Masterite	—	200°C.
Masteroil	—	Hot oils, fuels, organic solvents.
Super Masteroil	—	750 p.s.i., 480°C.

PLASTICS

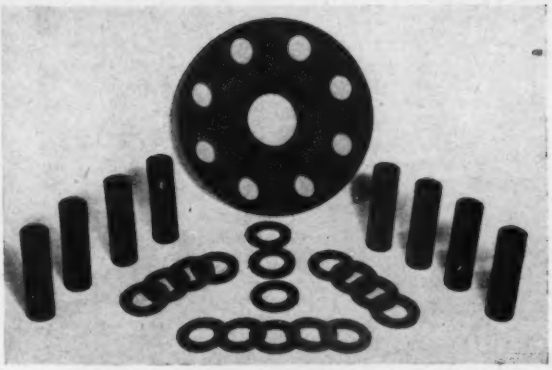
Range	Composition and Approp. Spec.	Suitable Environment
Atholl Asbestos & Rubber Co. Ltd.	Various grades to order.	
Bakelite Ltd.		
Vybak DVB 237	P.V.C.	Water, chemicals, heat. Weldable.
Beldam Asbestos Ltd.		
Ice	Plastics base.	All acids to 65°C.
Bell's Asbestos & Engineering Ltd.		
C2/P.T.F.E.	P.T.F.E.-filled white asbestos cloth	Most stringent chemical service from −200 to +300°C.
C22/P.T.F.E.	P.T.F.E.-filled blue asbestos cloth.	
British Resin Products Ltd.		
Styron	Polystyrene.	—
Rigidex	Polythene.	High resistance to stress crazing.
BX Plastics Ltd.		
Velbex	Flexible vinyl	Water and most chemicals.
Cobex	Rigid vinyl sheet.	Corrosive conditions. 60°C.
	With expanded metal core.	100°C.
Cobex/Velbex laminate	Rigid vinyl/flexible vinyl	—
Xylonite	Cellulose nitrate.	Dilute acids and alkalis.
Bexoid	Cellulose acetate.	—
Armourbex	Wire-reinforced Bexoid.	—
Lactoid	Casein-formaldehyde.	—
Bextrene	Toughened polystyrene.	Acids, alkalis, inorganic salts.
Isoflex	Multi-layer pads of corrugated cellulose acetate film.	Thermal insulation.
Bexthene	Extruded polythene.	—
Cooper & Co. (Birmingham) Ltd.		
Volaprene	Polyurethane foam.	Oils, solvents, chemicals.
Crane Packing Ltd.		
CF2 (various grades)	Treated p.t.f.e.	Corrosion resistant. 50–230°C.
Dunlop Rubber Co. Ltd.		
P.T.F.E.	Solid moulded or coatings.	Chemically inert −70 to +250°C. (under certain conditions to 300°C.)
Du Pont (U.K.) Ltd.		
Teflon	P.T.F.E.	−270 to +260°C. Chemically inert.
Delrin	Acetal resin.	Solvents. Low permeability. −40 to +130°C.
I.C.I. Ltd.		
P.T.F.E.	—	
Nylon	—	
Perspex	Acrylic material.	
Alkathene	Polythene.	
Vinyl chloride	P.V.C.	
Melinex (film)	Polyethyleneterephthalate.	
Richard Klinger Ltd.		
Klingerflon	P.T.F.E.	Chemicals, −100 to +250°C.
Precision Rubbers Ltd.		
Prescollan	Polyurethane.	Oil, fuel. −30 to +100°C. Sensitive to water and damp. Superior tensile, tear and abrasion resistance.
Polypenco Ltd.		
Polypenco nylon	Nylon.	
Fluorosint	P.T.F.E.	
Siemens Edison Swan Ltd.		
Clix P.T.F.E.		Moisture, chemicals. 260°C.
Clix P.C.T.F.E.		As p.t.f.e. Maintains properties to −200°C.
Volcrepe Ltd.		
Volaprene	Polyurethane foam.	Chemicals.
Whitby & Chandler Ltd.		
	P.T.F.E., p.v.c. and polythene.	Facings for base gaskets.
Wills Pressure Filled Joint Ring Ltd.		
P.T.F.E.-coated material	Coated glass cloth or metal gauze.	
Hostaflon P.T.C.F.E.	—	—
James Walker & Co. Ltd.		
Polonite	Plasticised p.v.c.	Dilute acids, alkalis to 40°C.
Fluolion	P.T.F.E.	Chemicals −80 to +300°C

VEGETABLE FIBRE MATERIALS

Range	Composition and Approp. Spec.	Suitable Environment
Anglo-American Vulcanized Fibre Co. Ltd.	Hard vulcanised sheet, flexible vulcanised sheet, Leatheroid, laminated Bakelite sheet (paper or fabric base).	
Geo. Angus & Co. Ltd.		
Invincible		Oil, water, gas, petrol, acetone, liquid ammonia.
Beldam Asbestos Co. Ltd.		
Benzoil		Petrols, oils, solvents. 200 p.s.i., 250°C.
Allied Hydraulic		Hydraulic fluids, oils, water. 3,000 p.s.i.
Bell's Asbestos & Engineering Ltd.		
Bestobell vulcanised fibre	(B.S. 216 and F60.)	Steam, water, oil petrol. 110°C.
J.101	Impregnated with solvent-resisting oil.	As above, to 120°C.
Chillcotts Ltd.		
X-fibre	Impregnated fibre	Oil, water, petrol.
Aero Grade	(D.T.D. 776.)	Oil, fuels. 120°C.
Paracor G	Vegetable fibre and cork similar to CS.2.	—
CS.2	Commercial quality.	Oil, petrol.
Oiled papers	—	Oil, petrol.
Coopers Mechanical Joints Ltd.		
Flexoid (F5)	Chemical wood, wood pulp with protein-type impregnant.	Oil, 100°C.
Buna-N coated Flexoid	—	Medium oil pressures and flange pressures.
Sizoid (F4)	Similar to Flexoid but still flexible after storage.	—
Buna-N coated sizoid	—	—
Treated Paper F6	Impregnated Kraft-type paper.	Oil, water, petrol.
Corbex	Impregnated fibre.	Oil, water, petrol. 120°C.
Fibrol (N)	Fibre base coated either with nitrile rubber or resin. With non-stick properties.	Oil resistant to 150°C. (nitrile), 170°C. (resin).
Untreated papers	—	—
Vulcanised fibre	Paper gelatinised by zinc chloride.	
Cork Manufacturing Co. Ltd.		
Oiled paper	—	Oil, petrol.
Vulcanised fibre	Red, grey and black. Hard or flexible.	Oil, petrol.
Leatheroid	Flexible fibre.	—
Fibron	Impregnated fibre base in three grades. Aero grade to B.S. 776.	Oils, petrol, grease. 130°C.
Oakenstrong	—	Oils, petrols, chemicals. 140°C.
Hall & Hall Ltd.		
Phiberoid	(D.T.D. 776.)	Oil, petrol, hot water.
Hamnett & Andrew Ltd.		
Vulcanised fibre		Oil, water. Normal temperatures.
Harold Jackson Ltd.		
Oakenstrong		Oils, petrols, certain chemicals. 140°C.
Ruberoid Co. Ltd.		
Bitumen-bonded kraft paper		
Richard Klinger Ltd.		
Klinger-Statite		Water, oil, gas, −40 to +120°C., 120 p.s.i.
Small and Parkes Ltd.		
Fepcolite	Vegetable fibre with glutinous binder and plasticiser.	Oils, fuels, solvents.
Stephens Gaskets Ltd.		
Kraft paper		
Manilla fibre		Oil and petrol to 120°C.
H. J. Stevens & Sons		
Various qualities.		
Vulcascot Ltd.		
Petrol jointing	Impregnated fibres.	Oil, petrol.
Vulcascot	With/without brass or steel wire reinf.	H.P. steam, oils, fuels, acids.
James Walker & Co. Ltd.		
Gaskoid	—	Oil, petrol. 120°C.
Vulcanised red fibre	Hard or flexible.	Oil, water, grease, petrol.
Whitby & Chandler Ltd.		
Various qualities.		



Corrugated metallic jointings made by the Metallic Manufacturing Co.



Tufnol gaskets, washers and spacers are assembled into pipeline couplings in the Middle East. They withstand the climate well and have reduced corrosion by electrolysis.

RUBBER-BASE MATERIALS

Range	Composition and Approp. Spec.	Suitable Environment
Atholl Asbestos & Rubber Co. Ltd.	Various grades to order.	
Beldam Asbestos Co. Ltd.		
Silicone rubbers	Sheet or moulded forms.	—
Lascaroil	Synthetic rubber.	Oil, petrol, solvents. 150°C.
Lascaracid	Blended rubber.	Acids. 90°C.
Lascar	Wire and fabric reinf. optional.	High temperatures, water, steam.
Bell's Asbestos & Engineering Ltd.		
Natural rubber	Solid or reinforced with fabric or wire gauze.	General purpose.
Neoprene rubber	Solid or asbestos fabric or wire gauze reinf.	Oils, acids, alkalis.
Nitrile rubber	Fabric reinf.	Oil, solvents.
Silicone rubber	Asbestos or glass cloth insert.	High temperatures and chemicals.
British Geon Ltd.*		
Synthetic rubbers	Nitrile	
Geon	P.V.C.	—
Chillcotts Ltd.		
Paroid synthetic rubbers	Neoprene and nitrile based, reinforced as required (D.T.D. 295).	
Clyde Rubber Works Co. Ltd.	Various brands of S.B.R., butyl, neoprene, nitrile, silicone and polyacrylic rubbers, polysulphide polymers and nitrile-p.v.c. blended polymers.	
Cork Manufacturing Co. Ltd.		
Neolangite	Neoprene and nitrile rubbers with cork.	
Chingford cork/rubber	Natural with cork	
Denton & Co.		
Natural rubber	—	
Asoil	—	
Neoplas	Synthetic rubber.	
Dunlop Rubber Co. Ltd.		
Silicone rubbers	Various grades.	
Du Pont Co. (U.K.) Ltd.		
Neoprene	—	Oil, grease. Sub-zero temp. flexibility.
Hypalon	Chlorosulphonated polythene.	Abrasion and ozone. Flexible at —40°C.
Viton	—	Oil, fuel, chemicals. 200°C.
Expanded Rubber Co. Ltd.		
Rubazote		
T. & W. Farmiloe Ltd.		
Nine Elms BR 1304 —uncured	Soft unvulcanised butyl compound. Becomes adhesive on application of solvent.	Form soft compression seals. Very resistant to weather ageing, sunlight, oxygen, ozone, acids and alkalis. High resistance to flex cracking. —57 to +150°C.
—composite	Core of vulcanised butyl, solid or sponge laminated with uncured butyl as above, or various metals, plastics, etc.	
BR 1107/9	Butyl based.	Water, vapour, alkalis, acids. 100°C.
SRM 205/9	Polysulphide based.	—
Hall & Hall Ltd.		
Hallprene	Butyl, neoprene, nitrile and silicone rubbers. To B.S., service and Admiralty specs.	
I.C.I. Ltd.	Various grades of S.B.R., nitrile and methyl methacrylate copolymers.	
Kautex Ltd.	Various grades of natural neoprene, nitrile and butyl rubbers.	
Richard Klinger Ltd.		
Klinger-Lastic	Synthetic rubber compounds.	150°C.
Klinger-Silon	Silicone rubber to D.T.D. 818 and other specs.	—90 to +250°C.
Long & Hambly Ltd.		
Natural, polyacrylic, silicone and nitrile rubbers	To standard specs. and to order.	—
Polychloroprene	—	Oil, ozone.
Polyisobutylene	—	—25 to +110°C. for weak acids and alkalis. Ozone.
Fluorinated silicone	—	Oil, fuels. —60 to +200°C.
Midland Silicones Ltd.		
Silastomer	Silicone rubbers.	—70 to +200°C. continuous service with intermittent use at —100 to +300°C.
North British Rubber Co.		
Rainbow No. 9	Natural rubber.	Hot and cold water, air, steam.
Precision Rubbers Ltd.		
Prescolastik	Silicone rubbers.	
Super Oil Seals and Gaskets Ltd.		
RN Rubbers	Synthetic rubbers.	Acetic acid, salts. —60 to +100°C.
BN ,,	—	Fuel oils, salts. —50 to +130°C.
M ,,	—	Formic acid, alcohols, gases. —55 to +130°C.
ER ,,	—	Alcohols, oils. —30 to +180°C.
SR ,,	—	Various salts. —60 to +120°C.
PB ,,	—	Lubrication oils, formic acid. —60 to +140°C.
S ,,	—	Glycol, salts, soap solutions. —70 to 250°C.
Small & Parkes Ltd.		
Karmal	Natural or synthetic rubber based.	
Ronald Trist & Co. Ltd.		
Seatrist Black	Black compound jointing.	Air, water and wet steam.
Seatrist C and B.303	—	Oil.
Volcrepe Ltd.		
Sponge rubber	Various grades.	
James Walker & Co. Ltd.		
Questo sheeting	Rubber composition.	Dilute acids and alkalis, water, L.P. steam. Special grade for oil.
Wallico	As above, with tinned steel gauze reinf.	—
Lion and W.B.	Rubber sheet with fabric reinf.	Water, L.P. steam.
Whitby & Chandler Ltd.		
Natural or synthetic rubbers	With/without reinf.	

JOINTING COMPOUNDS

Range	Composition and Approp. Spec.	Suitable Environment
C. R. Averill Ltd.		
Avarc	Various grades. Linseed oil and other bases with graphite filler, manganese, etc.	Steam, water, acids, alkalis. Special products to order.
Beldam Asbestos Co. Ltd.		
Deesol		450 p.s.i., 260°C.
Lascar caustic seal		Caustics.
Induro		315°C.
Lascidplas		Acids.
Lascarcem		650°C.
Lascaplast		200°C.
Bell's Asbestos & Engineering Ltd.		
Treatite		Petrol, oil. 1,000 p.s.i., 300°C.
Thomas Bishop Ltd.		
Permac		Steam, water, petrol, oils.
Cellon Ltd.		
Celloseal	(D.T.D. 369 and 900.)	Kerosene, esters, corrosive conditions.
Crane Packing Ltd.		
Cranpac plastic lead seal	Lead powder with insoluble lubricant base.	Water, gas, oil, petrol.
Graphite Products Ltd.		
Foliac		Water, gas.
Graphite compounds and manganese paste		Steam, water, gas, alcohol, acids, alkalis.
Red compound		As above, and oils and petrols.
White compound		Low-pressure water, steam, gas.
Held Glue & Compound Ltd.		
Heldite	(D.T.D. 777.)	Fuels, paraffin, water, oil.
Ruberoid Co. Ltd.		
Bitumen-type compounds		
Secomastic Ltd.		
Secomastic		Water.
Secomastic (Silver Tint)		Water.
Secostrip		Water, oils. −18 to +100°C.
Secostrip rubber bitumen		Water, dilute acids. Not petroleum oils. 50°C.
Philplug cold caulking compounds PC.3	Asbestos and cementatious materials.	Dilute acids, water. 1,000 p.s.i., 60°C.

Range	Composition and Approp. Spec.	Suitable Environment
Richard Klinger Ltd.		
D.D.L.		Oils, solvents, gases.
Kenilworth Manufacturing Co. Ltd.		
Hermetite liquid jointing	(D.T.D. 777.)	Steam, oils, fuels. 3,000 p.s.i. 360°C.
Red Hermetite 5400	Non-hardening paste.	Specifically for aluminium cylinder heads.
Diesel Hermetite paste 1282	—	Diesel fuel, detergents.
Flexible Hermetite 1326 B	(D.T.D. 900.)	Mineral and synthetic oils, kerosene, fuels.
Hermetite Dielectric Compound	(D.T.D. 369.)	To prevent electrolytic corrosion in metal joints.
Hermetite pipe-jointing paste	Easy break graphite jointing.	Hydrocarbons.
Plastic Hermetite 1310	Heavy, medium and light grades. (D.T.D. 900).	Oil, steam, fuels, gases.
Plastic Hermetite 1250	—	High temperatures.
Plastic-coil X 2 (graphited) or X 10	Propane/butane jointing paste.	L.P. gas sealing.
Double Bond fillers	—	Permanent sealing compound.
Slick Brands Ltd.		
Osotole	Liquid packing.	Oil, water, heat steam.
Telegraph Construction & Maintenance Co. Ltd.		
Telecompounds		Ambient temperatures.
James Walker & Co. Ltd.		
Liquid jointing	(D.T.D. 777.)	Steam, oil, solvents, gases. 370°C.
Lion universal paste	—	550°C. dry heat.
Lion non-setting compound	Remains plastic during service.	—
Lion manganese putty	—	Water, steam. 200°C., 200 p.s.i.
Lion pipe-jointing paste	Graphite or plain.	—
Plasid	—	65°C.
Butaplas	—	Butane, propane. 200°C.
Winn & Coales Ltd.		
Denso paste	Saturated petroleum hydrocarbons, inert fillers and passivating agents.	Non-hardening. Water, acids, alkalis, salts.
Denso mastic	Saturated petroleum hydrocarbons, inert fillers and vegetable and mineral fibres.	Resilient. Acids, alkalis, salts, water, gas.
Densyl Mastic	As above, but with asbestos fibres.	
Denso non-freezing grease	—	Non-hardening.
Caulking mastic 280	—	150°C.

FABRICS

Bell's Asbestos & Engineering Ltd.		
J.1.	Rubber-impregnated asbestos cloth with/without wire reinf.	Steam, water, gases. 315°C.
J.5	Asbestos cloth, proofed red rubber one side, graphited black rubber other side. Brass wire reinf.	Steam water, gases. 260°C
J.2	Semi-vulcanised white rubber-impregnated asbestos cloth, plain or graphited. Brass wire reinf.	Steam, water, gas. 260°C.
J.6	Non-metallic asbestos cloth, semi-vulcanised similar to J.2. Plain or graphited.	Steam, water, gas. 260°C.
Bellprene	Metallic and non-metallic asbestos cloth proofed with neoprene compound or with neoprene/asbestos insert.	Oil.
J.12	Non-metallic dry cloth woven jointing, rubber proofed one side.	500°C.
C102/S	Silicone rubber-proofed asbestos cloth.	Heat, chemicals.

Beldam Asbestos Co. Ltd.		
Lascaroil	Rubber-proofed cotton cloth.	
Dunlop Rubber Co. Ltd.		
Glass cloth	Proofed with silicone rubber.	
Hall & Hall Ltd.		
Petrolite	Cotton fabric impregnated with synthetic compound (D.T.D. 295).	Oil, petrol.
James Walker & Co. Ltd.		
Cotton sheeting	Rubberised fabric.	Hydraulic systems. L.P. steam.

LEATHER MATERIALS

Main suppliers of vegetable tanned and impregnated leathers: H. J. Stevens & Sons; Edgar Vaughan & Co. Ltd.; Chillcotts Ltd.; Super Oil Seals & Gaskets Ltd.

METALLIC MATERIALS

Main suppliers: Beldam Asbestos Co. Ltd.; Coopers Mechanical Joints Ltd.; Metallic Manufacturing Co. Ltd.; Plexial Ltd.; Wood Bros. & Co. (Gaskets) Ltd.; James Walker & Co. Ltd.

FELT

Plain and impregnated felts supplied by: Bury Felt Manufacturing Co. Ltd.; Coopers Manufacturing Co. Ltd.; R. Hamilton & Son; H. J. Stevens & Sons; Long Meadow Felt Co. Ltd.; Chillcotts Ltd. ; Dibyco Ltd.; Mitchells, Ashworth, Stansfield & Co. Ltd.

We acknowledge with thanks the co-operation of the companies mentioned on these pages in the preparation of this survey.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Toggle Joint Drum Brake

The essential design feature of an interesting brake drum developed in the Netherlands is a compass-type actuating linkage pivoted within the ends of the U-shaped shoe plates which are constrained to move radially in a straight line by means of slots provided in the anchoring plate. The toggle linkage is actuated at its fulcrum point by a centre cam rotated by Bowden cable or link-rod, the cams being shaped to ensure constant brake pressure irrespective of shoe wear conditions. Where three shoes are required instead of the more conventional two-shoe arrangement, a triple-head cam is used. The manufacturers, Becker, Brummen, claim that, compared with other drum brakes of the same diameter and lining width, improved braking power is obtained with a reduction in lining wear. Even after prolonged use, wear is uniform and constant braking power is maintained, with complete absence of the noises often associated with worn parts.

Refrigerated Rail Car

An improved form of construction for a refrigeration car produced in the U.S.S.R. is said to reduce the prime cost of transportation of perishable goods by 5-8 per cent. The eight-wheel car is approximately 56 ft. in length, with the body supported on a welded low-alloy steel frame. Considerable use has been made of suitable profiled steel metal sections for the vertical posts and sill members, the outer panelling being also of steel.

The internal walls are made from corrugated aluminium sheet, each section being separately fixed to the framing to prevent the formation of a continuous heat bridge. Insulating boards wrapped in foil are set between the inner and outer walls with asphalted paper inserted between the aluminium panels and insulant. The joint between door and frame is made with a double seal of rubber, one tubular and one solid, which extends along the entire perimeter of the frame. The refrigerating equipment consists of six stainless-steel tanks, located under the ceiling along the car, connected by pipes for draining the brine. A hatch for loading the ice and brine is located in the roof over each tank, the covers being stamped aluminium boxes filled with insulating material and coated with zinc on the underside. Slots in the inner roof and baffles of pressed wood fibre ensure an efficient air circulation. Five-and-a-half tons of ice are carried and the net carrying capacity of the car is 45 tons.

Microtubing

Tentatively named Sanotube Q, the Monsanto Chemical Co. are producing quartz fibre tubing 3/1000 in. diameter with characteristics desirable for many industrial applications. The tubing is flexible enough to be tied in knots without damage and has a tensile strength higher than that of many steels. It is resistant to high temperatures, inert to most chemicals and is electrically non-conductive. This quartz fibre tubing is expected to form part of the equipment used in the recovery of helium lost from natural gas. In a bench-scale model a mile of the tubing was used. In a full-scale production cell approximately 1½ million miles of the tubing is expected to be used.

Circuit Breaker

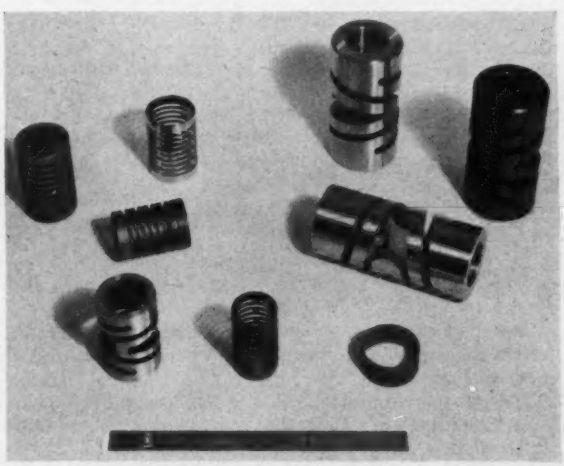
A new air circuit breaker installed in the Stalingrad-Moscow transmission line will be capable of handling 500 kV. at 200 amperes with a power-interrupting capacity of 20,000 MVA. The circuit breaker has a very efficient gas-filled arc extinguishing element and, to lower the switching, overvoltage is provided with special shunting resistors which also uniformly distribute the voltage between ten arc-quenching chambers. The current of the shunting resistors is interrupted by a disconnecting element with eight gaps arranged in series.

A unique oil-filled circuit breaker has also been designed to operate under the severe climatic conditions found in Siberia and the Urals, and consists of a bank of three single-pole breakers operated by individual d.c. electromagnetic drives.

Torsionless Instrument Springs

Wire-bound springs in spiral form are generally used for the measurement of forces and of their effects, and their degree of deflection provides the actual standard of reference. Theoretically, the springs are subjected to axial stresses, but, in practice, torsional effects occur during deflection, introducing errors of measurement caused by terminal friction retarding the return rotation when the stresses are removed.

This terminal friction is said to be eliminated in a new spring design recently introduced in Germany by Dr. Werner Röhrs K.G. Instead of being of coiled wire, the



Double helix construction of these springs developed by Consolidated Controls Corp. is said to eliminate any twist or turning moment between the end faces and thus avoid movements which introduce friction.

A new technique for extruding rubber sheathing over metal has been developed in the U.S.A. (see "Extruded Rubber Coatings").

springs are machined from metal tubing with annular slotting that is staggered to provide semi-circular flexure elements interconnected by solid sections so as to limit spring deflection.

Any desired loading, elasticity and response curve characteristic can be obtained by proper selection of slot configuration and distribution.

A similar type of spring was announced last year in the U.S.A. by Consolidated Control Corp. and is illustrated on page 41.

Glass Fibre Spray Moulder

A spray moulding machine recently developed in the U.S.A. by Fibrelay Inc. is said to enable several moulding functions to be performed. First, it sprays a continuous fibre, such as glass roving, sisal, hemp, cotton or nylon in continuous lengths with minimum of twist. Simultaneously, resin is sprayed from other nozzles on to the fibre. A third nozzle can be used, if desired, for spraying aggregate such as sawdust to provide bulk.

The addition of a binder along with the fibre is generally considered desirable, and it is possible to change the binder for controlling strength, cost or climatic conditions. A number of different types of liquid can be pumped and, while for glass fibre it is possible to spray catalysed resin from one nozzle and accelerated resin from the other, a lower-cost resin such as asphalte emulsions can be used. It is claimed that any pumpable liquid can be sprayed.

A particular advantage claimed for the machine is that continuous fibres can be sprayed, although chopping of the fibres can be accomplished if necessary. A variety of distribution patterns for the fibre is possible, so that parallel fibres can be alternated with random deposited ones. The moulder is operated entirely by air. Tanks and pumping unit are mounted on a trolley which can be quickly moved about. Output claimed is 2,000 lb. of moulded product an hour.

High-speed Plastic Tubing

A high-speed and continuous process for manufacturing reinforced thermoplastics tubing has been developed in France by Dr. Rene Imbert and M. Pierre de Vinzelles. Tubing is produced continuously at a speed of 6-8 ft./min., with the possibility of obtaining non-porous tubes able to resist an inner pressure as high as 1,500 p.s.i. or more.

The pipe-making unit is said to be compact enough to be mounted on a truck, so that the pipe can be produced on location.

Layers of glass fibre fabric, impregnated with polyester resins, are welded together into a rigid tube in a matter of seconds by a new high-frequency polymerisation method. Other resins or fibrous materials may also be used with similarly satisfactory results.

In general, the tubes that can be produced by the process are (1) a porous type mainly for structural purposes, chemical applications and electrical uses, and (2) the leakproof duct type for carrying almost any liquid or gas under pressure. The first type is said to be ideal for railings or ladders exposed to corrosive conditions or for lightweight sheds; a leading manufacturer of dies for the French car industry is said to be using this tubing for building up the die models of large body parts, because they are cheaper, easier to handle and are unaffected by humidity or temperature.

The Imbert-de Vinzelles process is not limited to tubing, but applies also to continuous manufacture of other products of infinite length.

The first of the machines has been in use in Normandy and is said to have proved so successful that plans are afoot to set up a similar plant on a ship to lay a projected pipeline across the Mediterranean from Algeria to the French coast.

Extruded Rubber Coatings

A new process that applies a continuous watertight extruded film up to ¼ in. thick over metal strips of various sections, including tubular sections, has been developed by Geauga Industries Co., of Ohio. Primarily developed for insulating high-voltage bus-bar, the extrusion method eliminates pulling an insulating sleeve over the conductor or dipping the metal in thermosetting plastics. Coverings can be provided in butyl, nitrile, neoprene or rubber, a natural bond being formed during the extruding process, and exceptionally close tolerances can be obtained on the coating thickness. The process is said to be applicable to both rigid forms and to flexible shapes such as braided wire and flexible tubing, and is ideally suited to atmospheric or moisture seals.

Pneumatic Analogue Computer

A pneumatic analogue computer has been developed in the U.S.S.R. for the solution of linear differential equations with constant factors, as well as simulation of systems of automatic controls, for both actual time scale and for modified time scale.

The adder-accumulator and integrator are the basic elements of the computer. A pressure of 0·5 atmospheres is taken at the zero level, so that a pressure above this figure represents a positive value. Pneumatic oscilloscopes or oscillographs can be connected to the output of the computer for visual observation of the examined process.

A third-order differential equation is said to have been solved on this analogue computer with an accuracy of 2·5 per cent. The instrument was produced by the Central Scientific Research Institute of Complex Automation.

High-strength Glass

A process for strengthening glass has been announced in Amsterdam by Glasindustrie F. van Tetterode. The process is said to consist of an acid treatment that is applied to ordinary glass in order to increase its strength and durability, and is followed by a silicone treatment that protects the treated surface of the glass.

Its commercial application in Holland so far has been principally to laboratory glassware and similar environments where it has evidently shown considerable advantage. It has also been shown by experimental work that it can confer on flat glass a considerable increase of strength, but it has been applied to very few practical uses of flat glass.

An option agreement for eventually practising the process in the U.K. has been granted to Pilkington Bros Ltd. Application has been made for a British patent.

ZINC ALLOY PRESSURE DIE CASTINGS

to B.S. 1004

Engineering Materials and Design

DATA SHEET No. 28

Chemical Composition, %

	Alloy "A"	Alloy "B"
Aluminium	3·8–4·3	3·8–4·3
Copper	—	0·75–1·25
Magnesium	0·03–0·06	0·03–0·06
Impurities (max. %)		
iron	0·10	0·10
copper	0·10	—
lead	0·005	0·005
cadmium	0·005	0·005
tin	0·002	0·002
thallium	0·001	0·001
indium	0·0005	0·0005
Zinc	Remainder	Remainder

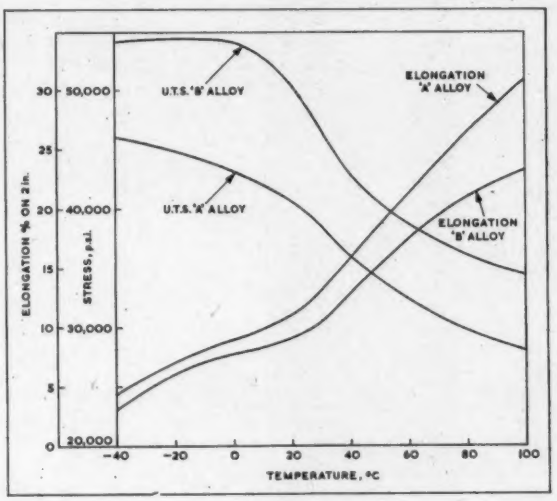
Physical Properties

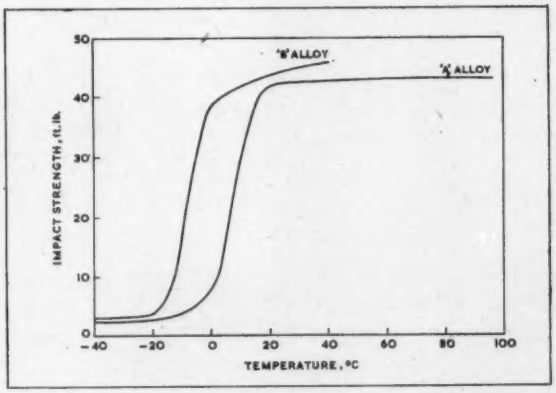
Specific gravity	6·7	6·7
Weight, lb./in.³	0·24	0·24
Melting point, °C.	387	388
Solidification point, °C.	382	379
Thermal expansion, per °C. (× 10⁻⁶)	27	27
Electrical conductivity, mhos/cm.³ at 20°C.	157,000	153,000
Thermal conductivity, cal./sec. cm.²/°C. at 18°C.	0·27	0·26

NOTE: Although zinc alloys may be sand or gravity die cast, the mechanical properties obtained by such means are somewhat inferior to those obtained by pressure die casting.

The variations in mechanical properties are reversible, and immediately normal temperatures are regained the original values are restored. In cases where the temperature is likely to be maintained for considerable periods of time, the maximum temperature for alloy "A" is 150 deg. C. for unstressed parts, and 100 deg. C. when stresses are involved. Alloy "B" is not recommended for parts exposed to heat.

Rates of corrosion vary according to the degree of atmospheric pollution, and are unlikely to exceed 0·0005 in. a year under the more severe industrial atmospheres and may be as low as one-tenth of this in rural conditions.





Mechanical Properties

Property	Alloy	Original Value	After 12 months' normal ageing	After 8 years' normal ageing	After 12 months' dry ageing at 95°C.
Tensile strength, t.s.i.	A	18·5	17·1	16·0	15·2
	A(S)	17·7	17·1	15·7	15·2
	B	21·7	20·7	18·9	16·5
	B(S)	20·2	18·8	—	16·5
Elong., % on 2 in. × ½ in. dia.	A	15·0	25·0	20·0	29·0
	A(S)	17·0	24·0	19·0	29·0
	B	9·0	12·0	14·0	23·0
	B(S)	10·0	14·0	—	23·0
Impact strength, ft.-lb.	A	42·0	43·0	44·0	37·0
	A(S)	45·0	41·0	42·0	37·0
	B	43·0	42·0	41·0	10·0
	B(S)	44·0	45·0	—	10·0
Brinell hardness	A	83·0	67·0	65·0	48·0
	A(S)	69·0	54·0	61·0	48·0
	B	92·0	74·0	74·0	64·0
	B(S)	83·0	72·0	—	64·0

A(S) and B(S) denote the alloy in the stabilised condition, after undergoing heat treatment.

Scabilising treatment consists of holding the castings for 3–6 hr. at 100 deg. C. Alternatively for 5–10 hr. at 85 deg. C., or for 10–12 hr. at 70 deg. C. allowing to cool slowly.

Shrinkage during Normal Ageing

	"A"	"B"
After five weeks	0·00032in./in.	0·00069in./in.
,, six months	0·00056 ,,	0·00103 ,,
,, five years	0·00073 ,,	0·00136 ,,
,, eight years	0·00079 ,,	0·00141 ,,

Shrinkage after Stabilising

	"A"	"B"
After five weeks	0·0002in./in.	0·00022in./in.
,, three months	0·0003 ,,	0·00026 ,,
,, two years	0·0003 ,,	0·00037 ,,

Recommended Stoving Treatment for Castings

Maximum times	½ hr.	1 hr.	2 hr.	3 hr.
Temperature, °C.	218	190	163	150

Data by courtesy Zinc Alloy Die Casters Association

EMD 1972 for further information

Can we help you with your pipe problems?

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians. Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipe-work is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

SEND FOR BROCHURE No. X17

Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

TEDDINGTON BELLOWS

EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LTD. (*Industrial Bellows Division*)
Ammanford, Carmarthenshire. Tel.: Ammanford 2255

THERMAL LINEAR EXPANSION OF BRASS AND ZINC

Engineering Materials and Design
DATA SHEET No. 29

New Books

Process Equipment Design. *By Lloyd E. Brownell and Edwin H. Young.* (*Chapman & Hall, 156s.*)

THE equipment under discussion is confined to storage tanks and vessels subjected to internal and external pressure, to high, ambient and low temperature. The problems treated are the selection of materials of construction, fabrication techniques, method of support and design of end closures and flanges, to mention a few which always arise the moment the vessel or tank ceases to be "just a vessel or tank" and becomes a structure within its own right.

The student and the young designer will both benefit by studying its contents and, while the reading of it is no substitute for their personal experience, they will be spared many pitfalls, as considerable engineering experience has been distilled into the pages. The authors have performed admirably in stating where a problem exists, they have given a reasonable if not always a complete explanation, and have pointed out sources from which further information can be obtained.

The preface states that one purpose of the book is to consolidate the basic concepts, industrial practices and theoretical relationships useful in the design of processing equipment. The book succeeds admirably in this purpose. It must be recognised that it is closely tied to U.S. industrial practice and codes, not suffering thereby, but it illustrates the need for a corresponding volume concerning British industrial practice and codes.

A. F. G. AUSTIN

Adhesives Guide. *By Joyce Hurd.* (*British Scientific Instrument Research Association, 20s.*)

Adhesives are now accepted as part of an engineering process, and their development has been so rapid that the number of types available has become bewildering. This situation has been realised by the B.S.I.R.A., who have published a guide which will greatly assist the design engineer in his understanding and selection of a suitable adhesive.

In the guide the choice is conveniently divided into groups, based on materials to which they may be applied, these again being subdivided, where necessary, into structural or non-structural components. Each basic type of adhesive is described and, being alphabetically arranged, is easy to locate. A further list classifies manufacturers, and additional tables indicate products under their trade names.

Internal Stresses and Fatigue in Metals. *Edited by G. M. Rassweiler and Wm. L. Grube.* (*Van Nostrand, 72s.*)

In selecting any material, it is important for the designer to have a knowledge of the internal mechanics in order to obtain optimum benefit. For this reason, a symposium organised in the U.S.A. in 1958 by General Motors to consider and interrelate the phenomena of internal stresses and fatigue in metals was an important occasion.

An edited version of papers read at the symposium is now available and deals with this phenomenon from the aspect of solid state physics and the phenomenological uses in designing cyclically stressed parts. It is a useful compilation of information for both metallurgist and designer. The first section of the book deals with the concepts and significance of internal stresses; the chapter on causes and effect is particularly useful. Part Two, "Crystal Lattice Imperfections and Stresses", is essentially for the metallurgist and physicist. "Dislocations, Internal Stresses and Fatigue", the third part, indicates the factors contributing to fatigue cracks and the effect of residual stress and strain loading, this being particularly important to designers.

The book is easy to read and the illustrations are well chosen to emphasise the text. A comprehensive index and a summary of the symposium make this book a valuable addition to the design engineer's bookshelf.

British Refrigeration Handbook. (*Refrigeration Press, 30s.*)

The ninth edition of this useful work has nearly 300 pages of classified information about low-temperature materials and equipment and their makers. Included are a quick reference index to who-makes-what, details of organisations concerned with refrigeration, and a selection of tables and other data intended principally for engineers working in the food cold storage and quick-freezing industries.

Gas Turbine Materials. *By G. Lucas and J. F. Pollock.* (*Temple Press, 25s.*)

Practical data on the behaviour of materials subjected to high temperatures are being continually sought by designers, and this book, using the gas turbine as a vehicle for the information, should be of considerable assistance. It opens with an outline of the development of high-temperature materials and leads the reader towards the behaviour of metals under stress and temperature. Subsequent chapters deal with applications of high-temperature materials. Metallurgical aspects, stress corrosion, creep and alloying effects provide a coverage of data associated with high-temperature design problems.

The Robertson Guide to World Screw Thread Standards. (*W. H. A. Robertson & Co. Ltd., 10s.*)

Providing comprehensive coverage of the many screw threads used throughout the world, this guide is segregated into various countries, giving standard references for equivalent thread series and form, enabling the reader to identify any thread shown on foreign drawings and relate it to the B.S. series. Not the least important part of this guide are the illustrated thread forms in existence which are fully dimensioned in terms of their pitch. Also shown is a series of self-tapping screws.

Asbestos: Its Industrial Applications. *By D. V. Rosato.* (*Reinhold and Chapman & Hall, 46s.*)

Asbestos in various forms is finding increasing applications in many branches of engineering, and here they are dealt with in a single publication. The various types of material are reviewed together with their properties. Subsequent chapters deal with asbestos cements and asbestos textiles, and the application of asbestos in specialised fields such as heat insulation, electrical insulation, friction materials, plastics, gaskets and filters.

Although the references to American standards may be difficult to relate to their British counterparts, the book is very well conceived and presented. An extensive bibliography adds to its usefulness.

LETTER TO THE EDITOR

Pioneers in Ergonomics

Sir,

In your editorial leader of November, 1959, you refer to the pioneer work in the field of ergonomics which has been carried out by two companies. It may be of interest to record that Metropolitan-Vickers have been engaged in ergonomic investigations since 1954 and have now reached the stage when an ergonomics laboratory is being established, and equipment re-designed as the result of ergonomic study is beginning to appear in production.

From the start, this work has been carried out as one aspect of the field covered by "Industrial Design", and we believe this combination is more effective than is the separate application of ergonomics, appearance and design methods.

The ergonomic work being undertaken includes layouts for special-purpose controls, and site and laboratory studies leading to re-design of standard control desks. More advanced studies are being carried out with a view to improving both the display of control information and linking of machines and operators.

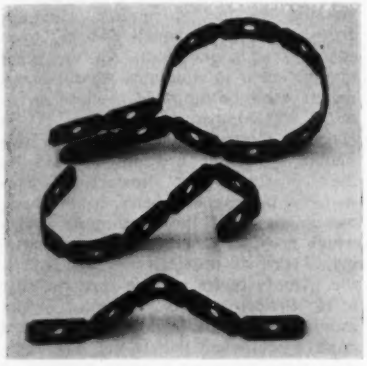
C. H. Flurscheim

Director and chief electrical engineer,
Metropolitan-Vickers Electrical Co.,
Manchester, 17.

WHAT'S NEW IN MATERIALS & COMPONENTS

Constructional Strip

Addyco steel strip is a notched and perforated material with a variety of possible applications. The V-notches are placed at 1-in. intervals to assist in measurement and marking off, and the $\frac{5}{32}$-in. dia. holes at 1-in.spacings alternate with the V-notches. The strip is said to be made in 16-S.W.G. (0·064-in.) good quality mild steel and is supplied in 18-in. lengths, bright electro-zinc treated. Addy Products (Sales) Ltd., Millbrook Trading Estate, Southampton.



EMD 2029 for further information

Rare Earth Metals

Successful production of all the rare earth metals is claimed to have been achieved by Johnson, Matthey & Co. Ltd. These rare earth elements or "lanthanons" comprise the fifteen elements from lanthanum to lutetium. Scandium and yttrium, the first two members of the same sub-group in the periodic table, are similar chemically in their atomic structure. Promethium does not occur naturally, but one of its isotopes has been isolated from the products of nuclear fission.

Improved techniques for the production of the metallic elements have now been brought to fruition, and all the fourteen naturally occurring elements, together with the closely related elements, scandium and yttrium, are now available in a variety of forms which have been remelted into ingots or rods. Lanthanum, cerium, neodymium, praseodymium and gadolinium have been successfully extruded and subsequently drawn to fine wire. Johnson, Matthey & Co. Ltd., 78 Hatton Garden, London, E.C.1.

EMD 2030 for further information

One-coat Enamel

An acrylic stoving enamel, known as Bergercron, is now being manufactured in this country. This finish, which is claimed to offer advantages in production because no primer is necessary, is said to give a harder finish and yet greater flexibility than any other paint on the market. It can be applied by dipping, spraying and flow-coating methods and is said to exhibit excellent adhesion to steel, aluminium and zinc alloys, giving a high-gloss finish with only one application. It is claimed to give excellent resistance to high temperatures and moisture and to be outstanding against detergents and hot fats. It is therefore recommended for domestic appliances such as washing machines, spin driers and dish washers, as well as more general engineering products. Stoving temperatures can be between 160 deg. C. and 200 deg. C. and times vary from 60 min. to 10 min. respectively. Lewis Berger (Great Britain) Ltd., Freshwater Road, Dagenham, Essex.

EMD 2031 for further information

MoS2 Grease

Molycue greases, made up from a combination of molybdenum disulphide and polyalkylene glycols with or without thickeners, are claimed to be useful synthetic lubricants for high-temperature applications under conditions where oil would burn. It is also said that their resistance to solvents is superior to ordinary lubricants and therefore they are of interest for chemical plants. Rocol Ltd., Swillington, Nr. Leeds.

EMD 2032 for further information

Aerosol Rust Inhibitor

Ambersil Electrospray is composed of a silicone-based anti-tracking fluid containing a rust-inhibitor, packed in an aerosol container. It is said to be well suited for use on aircraft cable plugs and sockets, leads and in all electrical equipment where good surface insulation is required under high humidity conditions. The properties claimed include high surface resisitivity, cleanliness in use, inertness, water-repellence, non-inflammability and excellent anti-stick qualities. Amber Chemical Co. Ltd., 11a Albemarle Street, London, W.1.

EMD 2033 for further information

Glass-cloth Impregnant

R.213 is a new silicone resin for flexible electrical insulating applications and has been designed especially for impregnating glass-cloth at improved coating speeds at temperatures of 100-120 deg. C. It is claimed to be superior to other cloth coating varnishes for operation at high temperatures.

It is said to wet glass-cloth very easily and to form a tack-free film on heating for as little as 5 min. at 120 deg. C. Glass tape coated with the resin has excellent flexibility and high electric strength, which are maintained at high temperatures, and it is said to be suitable for use as an insulating material in Class H and Class C motors, generators and transformers and other applications such as glass sleeving, flexible mica and mica-glass products. Imperial Chemical Industries Ltd. Silicones Dept., Stevenston, Ayr.

EMD 2034 for further information

Multi-purpose Primer

A general-purpose grey primer that will dry for handling in ten minutes is announced. Polyprimer, as the new product is called, is stated to be suitable for application by spraying, brushing or dipping and can be used on most metals and even hardboard. It is claimed that a wide variety of second coats can be used, and the primer is suitable as an anti-corrosion primer for out-of-doors weathering. Arthur Holden & Sons Ltd., Bordesley Green Road, Birmingham, 9.

EMD 2035 for further information

Solventless Varnish

A golden varnish which dries by polymerisation alone (there being no volatile matter in the accepted sense) is announced. It has been developed for use in electronic equipment for use in countries where exceptional climatic conditions exist. The types of windings normally treated with this varnish are usually of limited physical dimensions and are frequently wound with wires of very fine gauge. The conductor coverings are often of enamel, and interleaving of paper or other material may be used.

The varnish produces a tough, rubbery, void-free solid, and is said to be particularly stable, with good keeping properties. Its viscosity is stated to be such that it will flow quite readily at ambient temperatures. Excellent powers of penetration are claimed and it has no adverse effect on enamelled wire coverings. Normally applied in a vacuum impregnating plant, it can in selected circumstances be used in hot dipping conditions. Griffiths Bros. & Co. London Ltd., 59 Macks Road, London, S.E.16.

EMD 2036 for further information

High-temperature Adhesive

Hidux 1197, a new adhesive for temperatures up to 300 deg. C., is available in two forms. 1197A is for metal-to-metal bonding, and 1197B for honeycomb sandwich bonding. For simplicity and convenience in use, they are both supplied as films, and their storage is said to involve none of the difficulties associated with other types of high-temperature adhesive. Bonded Structures Division, CIBA (A.R.L.) Ltd., Duxford, Cambs.

EMD 2037 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
We shall be pleased to help readers who have difficulty in tracing sources of supply of materials or components.

Self-adhesive Film

For the protection of printed matter, drawings, etc., a product known as Halco-Sheen is announced. It is said to be particularly suitable for protecting drawings used in the workshop, where grease and moisture may be present. A piece of Halco-Sheen is cut to the required size, allowing a narrow margin for trimming after application. The special backing paper is separated along one edge and the adhesive side of the film applied to the material to be covered. The film is then smoothed down by applying pressure with a soft cloth, gradually releasing the backing paper until the whole surface has been covered. Both sides of the material can be protected in this way. J. Halden & Co. Ltd., Rowsley Works, Reddish, nr. Stockport.

EMD 2038 for further information

Link V-belting

Grey Knight link V-belting is made in M, A, B and C sections with 40-deg. angle and it claimed by the manufacturers to operate satisfactorily in the same V-grooves as continuous belting. The advantages claimed are that drives with fixed centres can be re-belted without dismantling the machine, lengthening and shortening being possible in a few minutes. Graton & Knight Ltd., Warwick Road, Boreham Wood, Herts.

EMD 2039 for further information

Non-Synchronous Timer

A number of new models of multi-stage non-synchronous timers are now available. The new units (known as series RCW 25) have been designed to provide a compact, inexpensive assembly suitable for building into resistance welding machines, and they incorporate switching arrangements for air valves and electromagnetic or ignition contactors. Three basic units are in production for two, three or four stages of time control. Lancashire Dynamo Holdings Ltd., St. Stephen's House, Victoria Embankment, London, S.W.1.

EMD 2040 for further information

Hard-facing Electrodes

The Cobalarc range of hard-facing electrodes is said to provide a complete range of hard-facing products which can be applied to almost any type of plant subject to abrasive wear.

The six types of Cobalarc electrodes are graded according to the properties of the deposit, with resistance to maximum abrasion at one extreme and maximum impact at the other. In between, the deposits combine varying degrees of impact and abrasion resistance as well as resistance to corrosive liquids, oxidation, etc. Fields of application for these products include the quarrying, dredging, earth-moving, mining, brickmaking, cement, iron and steel, chemical, gas and power industries and many others.

Diameters of the tubular Cobalarc electrodes go up to a maximum of $\frac{7}{16}$ in. and special moisture-proof coverings enable them to be stored under any conditions. The electrodes are said to be suitable for use with any conventional a.c. or d.c. welding power source. Quasi-Arc Ltd., Bilston, Staffs.

EMD 2041 for further information

Axial Fan

Now being marketed is a range of axial fans with special slotted blade formation which provide the choice of either higher efficiency or higher pressure ratios or a combination of both. Boundary layer control is also claimed to ensure that, with higher pressure ratios and minimum losses due to turbulence and blade friction, the fan size, running speed, airborne noise and structure-borne vibration are all reduced. The fans, which are intended for industrial, general marine and aeronautical applications, are to be sold under the tradename Ax-Slot. Keith Blackman Ltd., Mill Mead Road, London, N.17.

EMD 2042 for further information

Silicone Elastomer

Silastic LS-53, a recent addition to the silicone rubber range, is a fluorinated silicone elastomer and exhibits marked improvement over current grades of silicone rubber in its resistance to swelling and deterioration when immersed in most types of aircraft oils and fuels at service temperatures. It is claimed to have very good low-temperature flexibility characteristics and will function in service at temperatures of −60 deg. C. and below. Dunlop Rubber Co. Ltd., Aviation Div., Foleshill, Coventry.

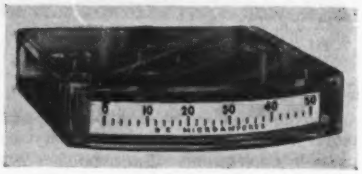
EMD 2043 for further information

Damp Protection Package

KD desiccators are claimed to be robustly-made aluminium units measuring 3 in. × 1 in. which are packed with granular silica gell as the desiccant. A special feature is the patented built-in indicator which shows immediately when the desiccator requires regeneration and when regeneration has been completed. The desiccant used is said to be non-toxic, odourless, non-corrosive and can be regenerated indefinitely by merely heating in an oven for about an hour. The capacity of the standard KD unit is sufficient to maintain dry conditions in an enclosed space of up to 5 cu. ft. for reasonable periods. The unit will absorb up to 2 oz. of water from the surrounding atmosphere before regeneration is necessary. Knapman, Jones & Partners, 7 Iddesleigh House, Caxton Street, London, S.W.1.

EMD 2044 for further information

Compact Edgewise Meter

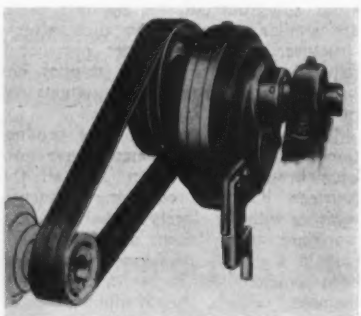


The model 220 range of meters, which can be supplied as voltmeters, millimeters and microammeters, has been developed for use in modern, complex, crowded control panels where front space is at a premium. An important application is in situations where several meters must be mounted in close proximity for comparative readings. It is claimed that, when mounted in this manner, readings are not affected by the proximity of meters, ferrous material or magnetic fields, as the basic movement is of the centre-pole design which provides inherent magnetic shielding. Types of application envisaged by the manufacturers include tape recorder level indicators, "S" meters, output monitors, indicators, automation and control equipment panels, etc. The edgewise meter occupies a space frontage of only 2·5 × 0·62 in. Taylor Electrical Instruments Ltd., Montrose Avenue, Slough, Bucks.

EMD 2045 for further information

Reduction Drive

The Ampulco Shaft-King speed reduction drive, by reason of the in-line layout embodied in the design, is said to enable a patented torque arm overload release to be fitted. This is said to ensure that, in the event of overload, the



torque arm falls free, thereby ensuring the safety of the driven machine. The unit is fitted with a taper grip bush to ensure that the drive is rigidly fixed and to enable the user to move the unit from one machine to another simply by changing the bush size.

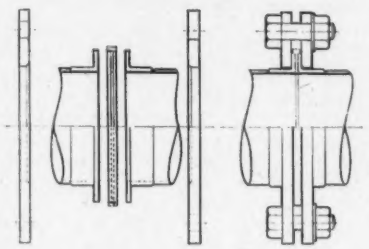
In addition to the torque arm overload release, the unit can also be fitted with a back stop either internally or externally and can also be flange mounted if required. William Kenyon & Sons Ltd., Dukinfield, Ches.

EMD 2046 for further information

Versatile Piping System

The Weltexa system of piping consists of standard parts in 1½-, 2-, 3-, 4-, 6- and 8-in. bore sizes fabricated from corrosion-resistant alloys. It includes all fittings normally required for a complete installation, and comprises straights in various lengths, bends, tees and standard reducers.

The system makes use of a specially designed taft backed by a B.S. Table "D" loose flange, and can therefore be connected to a very large number of existing installations with a minimum of difficulty. All parts are standard and interchangeable and can be built up, dismantled and rearranged by means of the standard reducers, complex systems of piping, from large to small bore.



Pipes and fittings are available in two types of stainless steel, but can also be supplied in other corrosion-resistant alloys. Welding Technical Services Ltd., King's Norton, Birmingham, 30.

EMD 2047 for further information

Variable Transformer

Type E401 BB/200 is an addition to the range of Philips variable transformers. Notable for its small size, it is designed for use on a 240-volt 50-c/s a.c. supply and will provide an output voltage continuously variable from zero up to 270 volts at a nominal current of 20 amps. A refinement claimed is in the provision of a unique multi-brush self-aligning contact coupled with a silver-alloy-coated track to minimise oxidation.

The transformer is obtainable in either enclosed or skeleton versions for bench or panel mounting. Units may be simply coupled for series parallel or three-phase use. It can also be supplied in a motor-driven form. Research & Control Instruments Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.

EMD 2048 for further information

Hydraulic Valve with "Feel"

The type 4879 valve from the Keelavite range has been specifically designed for the hydraulic operation of heavy-duty clutch and brake mechanisms, such as are used on cranes and winches, or any similar mechanisms which require constant manual control. Although the maximum pull required on the lever is only 18 lb., the full hydraulic pressure of 1,500 p.s.i. can be sensed and controlled. A given movement of the control lever will produce a resistance proportional to the movement of the hydraulic actuator. Three reduced pressures are available: 0-500 p.s.i., 0-1,200 p.s.i. and 0-1,500 p.s.i. Port sizes are all ¼ in. B.S.P. The valves can be supplied singly or in multiples up to six. Usually they are supplied in pairs for combined brake and clutch operation. They can be adapted for foot operation. Keelavite Hydraulics Ltd., Allesley, Warwicks.

EMD 2049 for further information

Panel Air Filters

A knitted wire mesh which is evenly wound on a Weldmesh grid and finished on the outside with Weldmesh, the whole being encased within a light metal housing, forms the basis of the Ozonair Dedust panel air filters, a new type of air filter specifically designed to ensure as near-to-perfect air filtration for electronic equipment and various other electrical machinery. Ozonair Engineering Co., 1 Longmore Street, London, S.W.1.

EMD 2050 for further information

Foot-operated Pump-ram unit

The Linford model 4000 combined hydraulic pump-ram unit is now available for foot operation, and is suitable for incorporation into lifting tables, elevating conveyors, and mobile and static stacking equipment. Owing to the necessity for spring return of the foot lever, the new version is single acting in the pump operation, but the arrangement is such that the oil displacement is equivalent to the double-acting hand-operated units. Five capacities, ranging from 1,100-4,400 lb., are available. No piping is required. Linford Engineering Co. Ltd., Baker Street, Birmingham, 11.

EMD 2051 for further information

Pneumatic Gauging

For multi-dimensional automatic gauging, a single size indicator that can readily be connected to any measuring circuit has been introduced. This unit is known as the model 91 "building block" and consists of a chassis housing a complete pneumatic circuit together with either two or four adjustable-pressure electric relays. The control signals are given by slave electrical relays which also operate signal lights on the front of the chassis. The model 91 operates on 230/250 volts, 50 c/s, and the change-over type contacts on the slave relays are rated at 5 amps 250 volts a.c. Air at any pressure between 60 and 150 p.s.i. is required for the pneumatic gauging circuit.

A multi-dimensional gauge is built up of the necessary number of "building blocks" together with a single-size indicator. To connect any pneumatic circuit to the indicator, it is simply necessary to operate the toggle valve on the front of each block.

Light signals show the condition of the workpiece and a size indicator is available to give quantitative readings when required. Teddington Industrial Equipment Ltd., Sunbury-on-Thames, Middlesex.

EMD 2052 for further information

Plummer Blocks

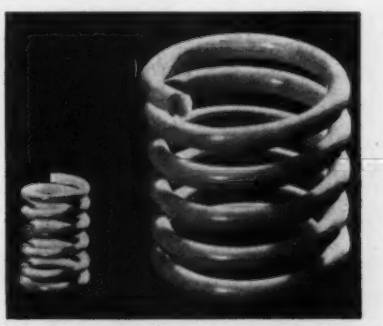
An anti-friction bearing for shafts up to 2½ in., which carry moderate loads, is provided by Fenner-Dodge type SC ball-bearing plummer blocks. Full self-alignment is provided by the spherical outer race of the ball-bearing which fits into the spherical seat in a cast-iron housing. Only non-expansion types are supplied. To exclude dust and dirt and to retain the lubricant, special seals are fitted which cannot be blown out when a grease gun is used.

A locking pin locates the lubrication hole and prevents rotation of the outer bearing race. This locking device is so arranged that if replacement of the ball-bearing is necessary it can be removed from the housing without disturbing it from its seating. The nine bore sizes range from ¼ in. to 2½ in. J. H. Fenner & Co Ltd, Marfleet, Hull, Yorks.

EMD 2053 for further information

P.T.F.E.-Coated Springs

Metal springs can now be coated with p.t.f.e., thus rendering them entirely impervious to attack by all substances with the exception of fluorine and the molten



alkali metals. Springs coated in this way are claimed to possess also the other characteristics of p.t.f.e., i.e., they are solvent resistant, non-sticking, unaffected by moisture, self-lubricating, etc.

The process is at present limited to certain types of tension springs with simply formed ends which should be closed but not ground, the terminations of the coils being spherically radiused and finally polished. The springs should be supported in adaptors made from the same material as the coating. Crane Packing Ltd., Slough, Bucks.

EMD 2054 for further information

Potentiometer Nut

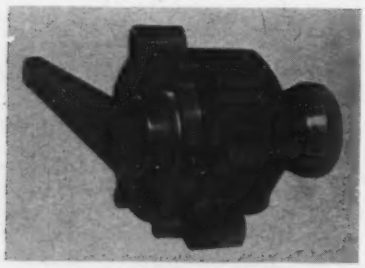
A new all-metal potentiometer anti-vibration nut has recently been marketed. This is made of aluminium alloy and has internal threads ⅜ in. × 32 t.p.i. and external threads ⅜ in. × 28 t.p.i. It has a spring steel, cadmium-plated locking insert which is said to give a highly consistent performance over much wider spindle tolerances than the existing Nyloc version.

The nuts can be supplied with identification washers made of light alloy 22 S.W.G. with anodised finish in six different colours. Simmonds Aerocessories Ltd., Treforest, Glamorgan.

EMD 2055 for further information

Adjustable Dashpot

The Kinetrol precision dashpot is now available in an adjustable-rate version. The manufacturers claim that with this silicone-filled damper any numerical value of damping within a 10:1 range may be obtained by setting the calibrated knob to the desired rate, and that there is a virtual absence of friction, thus ensuring purely viscous resistance.



Leakage and backlash are eliminated, because the shaft seal is a flexible rubber sleeve bonded to both the cover and the shaft and there is no surface at which sliding occurs.

Rates available are 2·0-2,000 lb. in./rad./sec. There is also a differential rate model which gives a large resistance in one direction only. Kinetrol Ltd., Trading Estate, Farnham, Surrey.

EMD 2056 for further information

Lift Suppressors

Interference to radio sets from electric lifts can, it is claimed, now be suppressed by fitting one of a new range of inductance-type suppressors recently announced.

Sparking occurring at the numerous relays and contactors in a lift installation, including gate release and floor trip mechanisms and interfloor calling devices, may cause radio interference by radiation from the wiring or metal work associated with the lift shaft or by direct injection into the mains. This new range of suppressors is claimed to have self-resonance at the centre of the frequency band in which the interference occurs, thus presenting a high impedence to those currents that are causing the interference.

Suppressors in this range are available at current ratings of between ¼ and 3 amps. They are connected in series with the relay contacts. Plessey Co. Ltd., Ilford, Essex.

EMD 2057 for further information

Joystick Switches

A range of new joystick control switches which are safer and more easily operated than conventional push-button systems has just been developed.

With manual or automatic return from two to eight positions, this new controller has many basic variations. The joystick has all the advantages of visual directional movement, plus the inclusion of an isolator for additional safety. This advance in sequence control technique allows a wide range of applications, all of which are said to require considerably less space and to be less expensive than an equivalent number of push-button units.

The controller consists basically of a varied number of robust switches mounted under a 3½-in.-sq. chromium top plate. They are grouped evenly each side of the square and are operated by a control lever which passes through an oil-filled spherical bearing. Pye Ltd., Cambridge.

EMD 2058 for further information

Drum Louvre

A new drum-type punkah louvre, designed for use with air conditioning, heating and ventilating installations in large enclosed areas, has been introduced. This is said to be an improved type of an existing version, and is built from aluminium alloy sections, making it light in weight and attractive in appearance.

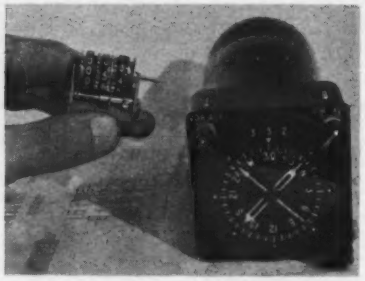
It has a throw of up to 120 ft. and can therefore distribute air efficiently over a wide area without the need for long runs of ductwork. It is available in eight sizes, from approximately 1-3 ft. long, with depths of 9 in. or 12 in. and can be mounted vertically or horizontally. Thermotank Ltd., international products div., 150 Helen Street, Glasgow, S.W.1.

EMD 2059 for further information

Miniature Counter

Small size and low torque are two of the major features claimed for a new 360-deg. counter-type indicator. The counter indicates by three-figure presentation the angular rotation of a shaft, for example. It can also be used to indicate the heading information on navigational equipment and is said to have many uses in aviation, marine and industrial fields.

Large, clear numbers and ½-deg. divisions make it possible to read the indicator to an accuracy of ¼ deg. It is stated that the old problem of what to do with figures on the middle drum above 5 when the indicated number has reached 359 and is moving on to 000 deg. has been simply overcome, only two layshafts being used.



The instrument is claimed to function satisfactorily in the range of temperatures between −40 and +70 deg. C. and to be able to withstand a fore-and-aft acceleration of 25 "g" without breaking loose from its mounting. Smith's Aviation Division, Kelvin House, Wembley Park Drive, Wembley.

EMD 2060 for further information

Pneumatic Valve

Included in the new range of Red Ring pneumatic valves now available is a five-port, direct-operated, double solenoid model that is claimed to be particularly robust. It is said to be very suitable for the control of air line pressure to double-acting cylinders and devices where electrical remote control is required in dusty conditions or where a heavy-duty valve is essential. It is available for ¼ in. and ½ in. B.S.P. with solenoids wound for all standard voltages. Stuart Davis Ltd., Bayton Works, Bayton Road, Exhall, Nr. Coventry.

EMD 2061 for further information

Spherical Bearing

A new low-cost spherical bearing rod end has recently been introduced in the Heim Unibal range. This bearing, for transmitting motion at varying angles and for problems of alignment, is a less-expensive rod end embodying most of the features of the standard types. It is available in male or female, right or left hand, B.S.F., unified or American threads from ¼-⅝ in. with ball bores from 0·25-0·525 in. Rose Bros. (Gainsborough) Ltd., bearings division, Albion Works, Gainsborough, Lincs.

EMD 2062 for further information

Spring Clips

A substantial saving is claimed to be possible in the cost of assembly and installation of fluorescent lighting units by means of a range of spring clips recently introduced.

The clips are manufactured from spring steel with a cadmium-plated finish, and are made in sizes to grip 2⅜ × 1⅛ in., 2¼ × 1¾ in., and 3 × 2 in. In addition to the saving said to be effected in assembly costs, the use of special safety straps and wires in the design of these clips is said to provide maximum security.

Other clips of similar pattern, but in a greater range of finishes and sizes, are also available for various applications. Lewis Spring Co. Ltd., Resilient Works, Redditch.

EMD 2063 for further information

News of Industry

The education section of the Council of Industrial Design has organised, at the request of **Hoover Ltd.**, a two weeks' residential course in design appreciation for ten Hoover staff members, including engineering designers, graduates and student apprentices. Emphasis will be on the appreciation of design from the æsthetic point of view.

The annual report of the **Council of Industrial Design** shows that last year seven industrial officers made nearly 900 visits to factories and showrooms, and attended twenty-eight trade fairs. As a direct result of these visits, says the report, 121 manufacturers approached the Record of Designers (operated by the C o I D) for recommendations or introductions. The total requests for the year for designers was 758, of which 177 were from the appliance and engineering industries and 205 from the craft and textile industries.

A. E. Griffiths (Smethwick) Ltd. have recently completed a plastics processing tank measuring 17 × 3 × 4 ft., their largest yet. It is constructed of two distinct layers of reinforced resins. The first, which is in contact with corrosive fluids, is made from furane, and the second consists of layers of reinforced polyester applied on the external surface, thus producing a twin-shell structure. The company has also used glass reinforced plastics in the development of a roof ventilating unit.

The **Institution of Electrical Engineers** has published a booklet entitled *Training Regulations*. This sets out the methods of meeting the training requirements of the institution through graduate or student apprenticeships, and also recognises that in certain cases effective training may be obtained by a junior engineer while holding a position on the staff of a chartered electrical engineer.

The first annual meeting of the **Society of Environmental Engineers** is to be held on March 30 in London. The organisation was formed last May to provide for the exchange of information among engineers concerned with the development of equipment to withstand shock, vibration and other forms of environmental conditions. Details from secretary, 42 Manchester Street, London, W.1.

An **International Pipes and Pipelines Exhibition** is to be held at Earls Court from May 30 to June 2 this year.

Semi-Elements Inc. announce that they have appointed **L. L. Light & Co. Ltd.** as their exclusive distributor in the U.K. The U.S. company is concerned with the research, development and production growing of single crystals.

The name of Synthetic Carbon & Engineering Co. Ltd. has been changed to **Morgan Components Ltd.**, to make clear its association with the Morgan Crucible Co. Ltd.

A method of remotely controlling the transfer of concentrated hydrochloric acid in measured quantities from storage to process vessel has been designed by **Liquid Systems Ltd.** Storage tanks are elevated sufficiently to give gravity feed to the measuring vessels, which consist of calibrated, vertical cylinders, fitted with electronic level detectors coupled to the control system. Movement of acid in the system is effected by compressed air by way of specially designed pinch valves operated by H.P. air cylinders and servos.

Gold-film windscreens of a greater curvature than previously has been possible, and designed for use in the latest high-speed aircraft, are to be produced in a new plant being built by the **Triplex Safety Glass Co. Ltd.**

Bendix Aviation Corp. has acquired a magnesium alloys patents licence from **Magnesium Elektron Ltd.** It will give Bendix the right to manufacture, use and sell in the U.S.A. castings produced by Magnesium Elektron techniques.

The **U.K.A.E.A.** plans to develop a site at the Royal Naval Airfield at Culham, Oxon, as a new research establishment. It would be used for research into controlled thermonuclear reactions and plasma physics and the study of nuclear fission as a possible source of industrial power. Most of the thermonuclear research now carried on at Harwell and Aldermaston would be moved there.

Publication of a complete English-language version of the Soviet journal, *Stal*, is now being carried out on a regular basis. The work is being done by the **Iron and Steel Institute**, by arrangement with the D.S.I.R. Specimen copy is available from the Institute at 4 Grosvenor Gardens, London, S.W.1.

The British subsidiary of the Dow Chemical organisation has changed its name to the **Dow Chemical Co. (U.K.) Ltd.**

The **Timber Development Association** is to hold a week-end residential course starting January 15 on the use and potential use of timber as an engineering material. It will consist of lectures, discussions and study visits on (1) scope of timber engineering, (2) nailed and connected joints, (3) modern adhesives and "glue-lam" techniques, (4) laminated timber and plywood construction, (5) shell roof construction, and (6) building by-laws and specifications.

Further details from T.D.A. Midlands regional officer, Chamber of Commerce Buildings, 94 New Street, Birmingham, 2.

Stainless steel as an external wall cladding is a feature of the new two-storey chemical laboratory at Sheffield of **Samuel Fox & Co.** The wall panels consist of 26-gauge stainless-steel sheets, electro-polished to a matt finish to prevent glare.

The **British Welding Research Association** has appointed Mr. Tibor Haas as head of the design section of its newly-formed Members' Service Department. He has been head of the fatigue department of Bristol Aircraft Co. for the past six years.

A new British company, **Electronic Associates Ltd.**, has been formed by Electronic Associates Inc. of New Jersey, U.S.A. The new company will design and construct special-purpose analogue computers and simulators.

Data Sheet No. 26 (Spring Steel Strip) published in our December issue contained two errors (1) 0·1 per cent proof stress should of course, read 0·01 per cent. (2) In the example given, the bend radius of the tool should read 0·0656 and not 0·656. We regret any confusion this may have caused.

This 32-ft.-long control rod standpipe, which was a feature of the Stewarts & Lloyds exhibit at the Scottish Industries Exhibition, consists of sixty-three tubes welded together, mostly inside the main casing tube. It is assembled to an overall straightness of 1 in 1,500. The standpipe and other components are being made for the Hunterston power station reactors.

EMD 1979 for further information

- Learn about this new conception of Smooth running.
- Even load distribution. Maximum permissible speed $\frac{300{,}000 \text{ r.p.m.}}{\text{shaft dia. mm.}}$
- All needles supplied to a tolerance of ±0·00004″ on diameter.

HEAD OFFICE AND FACTORY

INA NEEDLE BEARINGS LTD

Dept. E.M.D. Dafen,

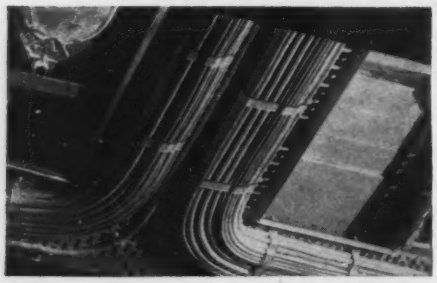
Llanelly.

Tel: LLANELLY 2056 and 2681
TELEX: 4816

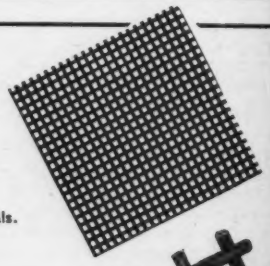
PLEASE WRITE FOR YOUR FREE COPY OF THE NEW TECHNICAL HANDBOOK

CAGE GUIDED NEEDLE BEARINGS

SOLE CONCESSIONAIRES FOR—INDUSTRIEWERK SCHAEFFLER, HERZOGENAURACH, WEST GERMANY

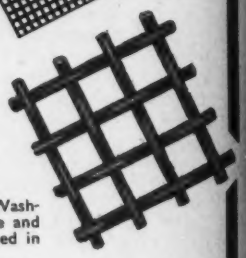


PERFORATED CABLE PLATES
in steel or aluminium alloy supplied in self-colour, painted or galvanised after manufacture. They are the most useful, permanent yet adaptable method of securing cables and conduits.



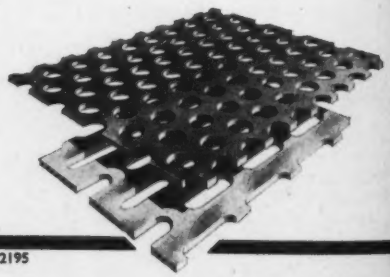
WOVEN WIRE CLOTH
accurate meshes in all commercial metals. Special weaves to specification.

'AGATE' STEEL VIBRATIN SCREEN CLOTHS
specially produced to withstand the abrasion and fatigue caused by prolonged service in vibrating screens.



PERFORATED STEEL PLATES
for Jig and Trommel Screens, Wash-Boxes etc. Any size and shape and pattern of hole can be produced in all Commercial Metals.

WEDGE WIRE SCREENS
The most efficient screening surface for many screening, filtering and draining problems. Greenings Wedge Wire screens have proved themselves efficient under the most arduous conditions.



Greenings
N. GREENING AND SONS LTD.
BRITANNIA WORKS
WARRINGTON · ENGLAND
P.O. BOX 22

EST. 1799 TEL.: WARRINGTON 32401 GRAMS: GREENINGS, WARRINGTON TELEX NO. 62195

NG.84

EMD 1980 for further information